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MAINE APPLE DISEASES

This bulletin treats of the various diseases of Maine apple trees and fruit other than those caused by insects. A subject index arranged to assist in the identification of the different diseases will be found on page 392.

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BULLETIN No. 185.**MAINE APPLE DISEASES.****W. J. MORSE AND C. E. LEWIS.****INTRODUCTION.**

While Maine is well to the north of the apple-growing section of the United States, there is no settled part of the State where at least some varieties of eating apples cannot be grown successfully. Even in northern Aroostook in the latitude of Quebec certain of the Russian varieties, and some of the more hardy apples of American origin, are grown to perfection and are of a quality unexcelled. Moreover these varieties are perfectly hardy there, sometimes withstanding temperatures of —40 degrees F. and below. During the winter of 1906-7, when southern Maine and certain other parts of New England and adjacent portions of Canada suffered great loss from winter killing of apple trees, practically no damage was observed in Aroostook County.

Fortunately or unfortunately, as it might be regarded from one point of view, climatic and soil conditions are such in Maine that a fair crop of good apples can be produced usually with a minimum of care and attention. In too many instances in years gone by the owner has not felt the necessity of giving his orchard any attention after setting the trees other than to harvest the grass which grows therein and to pick an occasional crop of apples which may be produced; cultivation, if any, being secondary as a result of growing some annual crop in the rows between the trees. The fact that a considerable number of trees would survive this treatment, producing fair returns for the labor involved, has in the past materially helped to delay the general adoption of more approved systems of orchard management.

Competition with apples produced farther West, which command a higher price simply on account of more attractive appearance and packing, has resulted in rapidly increased attention to and adoption of better methods of orchard management. In every case where these improved methods have been introduced, the results have far exceeded expectations. At the same time there has been within the last few years a combined and united effort among the various agencies in the State which are concerned in the furtherance and betterment of the agricultural and horticultural interests to bring about the production of more and better fruit in Maine. As a result of these various factors working together, the old let-alone methods of orcharding are rapidly passing. Old orchards are being trimmed and renovated and orchard cultivation and spraying are yearly receiving more attention. Not only are the old orchards receiving better care, but probably more new trees have been set in 1910 than in any other single year in the history of orcharding in the State.

With increased attention to the welfare of the trees, the owners are becoming aware of the fact, as never before, that there are various diseases which impair the health of the tree by attacking the trunk, limbs and leaves, which also are detrimental to the appearance and keeping qualities of the fruit. Therefore, in response to many inquiries addressed to the Station for information along this line, it has seemed best to prepare a somewhat comprehensive publication upon the nature and treatment of Maine apple diseases. While, as far as possible, the results of studies and investigations made at this Station are made the basis of the recommendations given, the published reports of work in other parts of the country have been freely drawn upon where necessary.

Published data with regard to the nature and extent of Maine apple diseases is rather meager. Therefore it is hoped that in addition to providing descriptions and giving methods for the control of the more common diseases which interest the orchardist that this publication will be of some value in extending the known range of the various diseases of the apple and in a measure give some idea of their prevalence and distribution in the State. With this end in view some few diseases, particularly some of the apple decays, which are either new or little

known in America, but which have been found in Maine, have been mentioned and briefly described. As a rule these are not of much economic importance in the State. Similarly a description of some diseases, like the bitter rot of the fruit, which occur to a slight extent in the State have been included because these are of great economic importance in other parts of the country. These latter may or may not become factors in Maine orcharding, but it seems desirable that all apple growers become familiar with their characters.

CHARACTER AND CAUSES OF APPLE DISEASES.

If we accept a rather broad definition that disease in plants includes the effect of every unfavorable factor entering into the life of the plant it follows that various agencies of the living and non-living environment may be responsible for the condition known as disease. While it is not always easy or convenient to discuss the disease apart from the cause, it should be kept clearly in mind that the parasite or other exciting factor is not the disease. The latter is the condition induced in the host as the result of the presence of the former, rendering the plant partly or wholly incapable of responding to its environment. Therefore all methods of disease control should be based upon an as extended and as detailed knowledge as possible of the responsible factor or factors regardless of their nature, but it is important as well to be able to recognize the outward manifestations or signs of the disease upon the host to aid in its identification. The outward manifestations of plant diseases are frequently not apparent until too late to remove the cause and save the plant or fruit. Hence from their character and mode of attack preventative measures must be largely relied upon to prevent losses from plant diseases, particularly those which attack the apple.

Those diseases which are induced by unfavorable soil and climatic conditions or other non-living agencies are said to be *non-parasitic*. Those which result from the attacks of various forms of organic life upon the host or from their presence within its tissues are classified as *parasitic* diseases.

This bulletin is concerned with certain non-parasitic diseases and those parasitic diseases of apple trees and fruit in Maine which are produced by fungi and bacteria. For a detailed dis-

cussion of the various insect parasites of Maine orchards and the means by which they may be controlled the reader is referred to a circular recently published by this Station on the Apple Tree Insects of Maine.

In this State fungi are responsible for the major part of the loss from the diseases under consideration. Fungi are low forms of plant life made up of threads of microscopic size. These threads constitute the *mycelium* of the fungus, which penetrates into the tissues of the host, causing the death of the cells which compose these tissues and living upon their contents. The conspicuous portions of the fungus which are seen on the surface of the host are in most cases the fruiting organs. Instead of seeds these fruiting organs produce various forms and in various ways, often in vast numbers, more simple bodies which are known as *spores*.

In combatting apple diseases caused by fungi, the chief object is to prevent the formation of these spores, or if they are formed to destroy them before they can germinate and gain a foothold upon healthy fruit, foliage, or wood. This is more frequently brought about by destroying the diseased portions as soon as observed and by coating or spraying the healthy parts with some substance which will prevent the germination and destroy the spores if by chance they fall thereon.

The threads of many fungi are colorless, while others are more or less colored or darkened, but all are devoid of the green coloring matter which enables the higher plants to manufacture their food substances, through the aid of energy obtained from sunlight, from the simpler compounds which they get from the air, soil and water. Hence fungi and bacteria which are also deficient in green coloring matter must depend upon more complex organic bodies to supply their food materials. Through the action of various ferments which they produce, parasitic fungi can break down and destroy, with varying degrees of ability, the tissues of their host plants. The results of this decomposition furnish them the food materials necessary for their maintenance and growth. The threads of a wood destroying fungus may be penetrating deep into the interior tissues of an apple tree, causing their death and decay with very little evidence of disease upon the surface. In fact the conspicuous, external symptoms do not as a rule appear till the fungus has

used up considerable of the available food material and throws out fruiting organs on the surface.

Those fungi and bacteria which are able to attack living bodies are said to be *parasitic* or *parasites*. Those which secure their nourishment from dead organic matter are designated as *saprophytic* or *saprophytes*. The saprophytes far outnumber the parasites and the majority of them cannot under any condition cause disease. However, there is no hard and fast line between the two classes. Some fungi which ordinarily live as saprophytes may, under favorable conditions, attack and destroy living plant tissues. Some fungi are obligate parasites but a large number of the disease producing forms are capable of a saprophytic mode of existence as is shown by the fact that they may be successfully grown upon a variety of artificial culture media. This fact is of great importance to the orchardist. Dead limbs, piles of rubbish and rotted fruit which frequently are allowed to accumulate in the orchard are breeding centers for those fungi which attack the fruit, leaves, and wood of the tree. Hence the first step in removing the cause of disease is thorough orchard sanitation.

NON-PARASITIC DISEASES.

Winter Injury. Those parts of Europe and Asia where the apple is native have very moderate rainfall and are not subject to such wide range and abrupt changes of temperature as in this State. The northern limit of range of the apple except in the case of the very hardy varieties is determined approximately by the lowest winter temperatures, or -30° to -32° F., repeated at frequent intervals. Some varieties, like the Baldwin and Ben Davis, in Maine apparently are liable to be injured where the repeated minimum winter temperatures are several degrees warmer than this.

Other conditions also enter into winter killing, such as deficient rainfall in spring and early summer followed by a late fall, thus preventing early growth, maturity and ripening of the season's wood. Similarly too, late cultivation and the application of large amounts of fertilizer rich in nitrogen may also stimulate to late growth and prevent ripening of the wood before cold weather comes on, and predispose to winter injury. The amount of moisture which the plant cells contain at the time

the low temperatures are experienced is also a contributing factor. The more water they contain, beyond certain limits, the more likely will they be injured by freezing. This probably accounts for the fact that very frequently in Maine the trees in the more exposed locations have suffered less from winter killing than those in more sheltered situations. There was better drainage, the ground frozen more deeply and the roots chilled and inactive and not supplying water to the plant tissues above.

The severe winter killing of 1906-7 was probably due to the combined influence of low temperatures alternating with high and a large percentage of water in the tissues of the trees. Weather conditions of January, 1907, were particularly favorable to this as will be seen by examination of Fig. 237 which shows within a week a record of -40° F. and -35° F. with two warm days having a maximum temperature of $+45^{\circ}$ F. and $+47^{\circ}$ F. situated midway between. Moreover it will be seen that the changes from extreme cold to thawing and back to cold again were quite abrupt, particularly in the case of the latter. Winter killing of trees may occur, however, as the result of a deficiency of moisture in the soil associated with continued cold, dry winds in winter.

Much of the danger from winter killing can be avoided by planting only those varieties which have been found to be perfectly hardy in a given locality. Only the most hardy varieties should be planted in those parts of the State where the minimum winter temperature frequently reaches or approximately reaches -30° F. The planting of Baldwins and possibly Ben Davis as large commercial ventures should be restricted to those parts of the State where the minimum winter temperature, repeated at frequent intervals, seldom reaches below -20° F. or at the utmost -25° F. The location of the orchard may have much to do with hardiness. Low, heavy or wet soils should be avoided,—it was orchards in such locations which suffered most in the severe winter killing of 1906-7. Those which were located on more or less sloping land with good air drainage, with plenty of natural or artificial soil drainage as a rule suffered much less from winter injury.

There is considerable difference of opinion among Maine orchardists with regard to the value of wind-breaks. A very good illustration of the good they may do was furnished by an Orono orchard following the severe winter just referred to.

This orchard was badly injured, particularly on the north and northwest sides of the more exposed trees and in the direction from which come the prevailing cold winds of winter. A natural wind-break of evergreens and coppice growth was situated so as to protect a portion of the trees and here the injury was much reduced or absent altogether.

Aside from the possible value of planting wind-breaks very little can be done to prevent winter injury in orchards already planted except to provide artificial drainage where necessary and to avoid forcing the trees to too luxuriant and late growth during the latter part of the season, as has already been mentioned. However, much of the ill effects following an adverse winter may be eliminated by proper attention to the injured trees. Observations made in Maine orchards for 4 seasons following the winter injury of 1906-07 have convinced the writers that as much if not more damage has occurred indirectly from the attacks of fungi following the winter injury and which gained entrance through the wounds thus made than as a direct result of the winter injury itself. In many cases very little was done to remove the injured parts and they were allowed to decay and serve as breeding places for wood destroying fungi. Later this decay followed back along the injured limbs or into the interior of the trunks, resulting in the death of the entire tree.

While severe pruning and cutting back immediately following winter injury is not advocated, all dead wood should be cut out as fast as seen and the wounds at once covered with a good liquid grafting wax or two or more coats of pure white lead in boiled linseed oil, and then repainted as frequently as necessary to keep the wounds well coated till they are covered with the new growth.* The dead bark on trunk and crotch injured areas should be removed back to healthy tissue and the wood thus exposed kept well covered with grafting wax or pure

*In some instances severe injury to the trees has been reported where the entire trunks have been heavily coated with lead and oil, to prevent insect attacks. This may be due, however, to the use of impure lead and either unboiled oil or some substitute for linseed oil. In the writers' experience, and so far as can be learned, the use of pure white lead in boiled linseed oil has been universally successful in treating wounds made in pruning.

white lead and boiled linseed oil. Bridge grafting may be used where collar freezing occurs.

Crotch injury. Associated with the winter killing of 1906-07 many of the injured trees showed the bark killed in the crotches as illustrated in Fig. 238. A similar trouble was observed in Ontario and other parts of Canada. There is some difference of opinion as to just how this crotch injury was produced, but there is no reason for regarding it other than as one form of winter injury. This should not be confused with a similar trouble caused by the pear blight bacillus which has been described by Whetzel in New York.

Frost bands on fruit. Occasionally late frosts occur which are not sufficient to destroy the young fruit, but do result in a peculiar characteristic russeting. As the apple enlarges and approaches maturity this appears in the form of a band of varying width extending entirely around the fruit midway between the stem and calyx.

Frost injury of the leaves. Very frequently associated with frost bands on the fruit there is more or less injury on the foliage. This has been described by Stewart and Eustace as follows: *

"On the upper surface the leaves were variously wrinkled and puckered, but the under surface was fairly even and normal in appearance except for certain areas on which the color was gray green. On some trees the leaves were badly distorted with the margins drawn downward and together as if they were unable to unfold properly. Usually the wrinkles were most abundant along the mid-rib of the leaf and the elevated portions were of a somewhat lighter green than the other parts of the leaf. By cutting across the leaf with scissors it was found that where the wrinkles occur the lower epidermis is separated from the green, pulpy tissue (mesophyll), thus forming a large interior cavity or blister. The distance between the green tissue and the loosened epidermis was frequently as much as four millimeters (one-sixth of an inch), and the blisters thus formed were of all sizes up to those having an area of 100 square millimeters or even more. In many cases the separated epidermis became ruptured as if slit with a knife, leaving the cells of the

* Stewart, F. C. and Eustace, H. F. N. Y. Expt. Sta. Bul. 220 p. 218

mesophyll exposed. Sometimes the tender cells thus exposed died, causing the formation of an irregular, dead, brown spot, visible on both surfaces of the leaf. However, in the majority of cases the exposed cells remained green throughout the season."

They ascribe this to a frost occurring about the 10th of May, and the appearance of the trouble first came to their attention about June 1. They state that in 1902 this condition was general throughout New York except in the Hudson Valley and on Long Island. A similar condition has appeared in Maine but no such general occurrence has been observed by the writers. This curling of the leaves as the result of early frosts should not be confused with that caused by apple scab, aphids or plant lice.*

*Protecting orchards from frost.*** The apple crop in Maine, as in many other parts of the country, is often materially reduced and in some sections may amount to a total failure as the result of frosts occurring at blossoming time or when the fruit is small. From time to time the question of starting fires and smudges in the orchards on cold nights to ward off the frost has been agitated, but the practicability of this has remained more or less of an open question. Recent work in the far West indicates that it is entirely possible, under some conditions at least, to prevent the destruction of the crop in this way at relatively small expense. Interested parties are advised to write to the Secretary of Agriculture, Washington, D. C., for the free Farmers' Bulletin 401 which tells how this work is done.

Mr. P. J. O'Gara, the author of this bulletin, says: "The results of the past season's work in the Rogue River Valley have shown that many acres of crops valued at from \$500 to \$1,000 per acre have been saved at a total expenditure of not more than \$15 to \$20 per acre for firing. Very striking examples have been seen where unsmudged orchards adjoining those that have been smudged have borne no fruit."

* See pp. 16 and 17 of the Circular on Apple Tree Insects of Maine, already referred to on p. 340.

** For many practical suggestions with accounts of successful commercial tests in several states in protecting orchards from frost at blossoming time the reader is referred to the special "Orchard Heating Number" of Better Fruit. Vol. V, No. 4, October, 1910.

Russetting or spray injury of fruit. Bordeaux mixture, some of the prepared brands of lime-sulphur, and to a less extent home-cooked and self-boiled lime sulphur spray, may produce a russetting of the fruit.** The relative merits of lime-sulphur and bordeaux mixture as a spray for apple trees will be discussed elsewhere in this publication.

Experience at other places and at this Station has shown that bordeaux mixture is more likely to produce spray injury than most of the lime-sulphur sprays now on the market. Bordeaux injury first appears as small, regular, black or brown spots, scattered over the apple, but more frequently on those parts which received the most spray. These spots differ from those caused by the apple scale fungus in that they are more regular and are not sunken. As the apple grows these spots are replaced by russeted blotches. In severe cases the fruit may become distorted, irregular and sometimes cracked. Fig. 239 represents the later stages of bordeaux injury on the fruit.

The following list prepared by Hedrick classifies apples according to their immunity to bordeaux injury.†

"1. *No injury or very slight.*—Alexander,* Alton, Bitterheimer, Bloomfield, Baxter, Canada Baldwin, Doctor, Doctor Waller, Dutton Junior, Dutton, Early Harvest, Esopus Spitzenburg, Fall Pippin, Fall Wino, Fishkill, Florence, Gano, Golden Russet, J. J. Jones, Keswick, Northern Spy, Oliver, Perry, Pomme Grise, Ralls, Red Canada, Richard Early Winter, Rome, Roxbury, Rutledge, Smokehouse, Stump, Swain, Throck,* Tompkins King, Yellow Bellflower.

"2. *Slight injury.*—Buckingham, Chenango, Clayton, Elgin Pippin, Fallawater, Fairbairn, Fanny, Golden, Grimes, Haas, Holland Winter, Hubbardston, Jewett, Karabowka,* Lady, Lady Sweet, Landsberg, Louise, McIntosh, McMahon, Maiden Blush, Monroe Sweet, Munson, Oldenburg,* Ontario, Pewaukee, Primate, Prince Albert, Pumpkin Sweet, Red Astrachan,* Reinette Pippin, Saint Lawrence, Shannon, Standard, Stark, Sutton, Te-

** For an account of spraying experiments conducted in 1910 with a discussion of the spray injury from lime-sulphur and bordeaux mixture the reader is referred to a forthcoming bulletin of this Station by Mr. W. W. Bonns, the Station Horticulturist.

† Hedrick, U. P. N. Y. Expt. Sta. Bul. 287, p. 142, 1907.

* Russian varieties.

tofsky,* Tolman *Sweet*, Tufts, Wallace Howard, Washington Strawberry, Western Beauty, Williams, Wolf River, York Imperial. Crabapples—Excelsior, Montreal Beauty.

"3. *Badly injured*.—Autumn Streaked,* Barry, Belborodoo-skoe,* Ben Davis, Borsdorf,* Boskoop, Canada Reinette, Constantine,* Cooper Market, Czar Thorn,* Ewalt, Flory, Golden Sweet, Gravenstein, Hurlbut, Jeffris, Jersey Sweet, Kalkidon,* Lankford, Late Duchess,* Longfield,* Milden, Milwaukee, Monmouth, Mother, Nero, Newman, Northwestern *Greening*, Ostrakoff,* Paragon, Parry White, Peck *Pleasant*, Peter, Rambo, Red June, Scott, Smith Cider, Sops of Wine, Switzer,* Wagener Improved, Walbridge, Washington Royal, Wealthy, White Pippin, Windsor, Winesap, Workaroe,* Yellow Newtown, Yellow Transparent.* Crabapples—Chicago, Coral, Hyslop, Martha, Paul Imperial, September, Transcendent, Whitney.

"4. *Very badly injured*.—Baldwin, Collamer, Jonathan, Mann, Red Transparent,* Repka,* Rhode Island *Greening*, Romna,* Saint Peter,* Twenty Ounce, Vineuse Rouge,* Winter Banana, Wagener, Yellow Calville.*"

Much of the injury from bordeaux mixture may be avoided if proper attention is given certain factors which have more or less to do with its occurrence. Too strong bordeaux should not be applied—a 3-3-50 mixture is recommended. The lime should be of good quality and approximately equal parts of lime and copper sulphate should be used. Never pour concentrated solutions together—equal and full dilution of the milk of lime and copper solutions should be made before mixing. Cover the fruit and foliage with a fine mist, but do not apply sufficient mixture to cause the trees to drip. Do not spray during rainy, foggy or damp weather. Study susceptibility of varieties. Those varieties which are listed above as badly or very badly injured by bordeaux mixture, and any others which the orchardist's experience indicates should be placed in this class, should not be sprayed with bordeaux mixture after the leaves begin to unfold. Past experience has shown that under Maine conditions with those varieties like the Ben Davis which are quite susceptible to spray injury, the ill effects resulting from the application of bordeaux mixture, except early in the season, have equalled or exceeded the good. As is indicated elsewhere

* Russian varieties.

in this publication (p. 378) there is considerable reason to believe that some form of the lime-sulphur sprays in proper dilution may be of service on such varieties. Bulletin 135 of the Illinois Station by Prof. Chas. S. Crandall, and Bulletin 287 of the New York (Geneva) Station by Prof. U. P. Hedrick, treat of bordeaux mixture and bordeaux injury in relation to the apple in a very comprehensive and exhaustive manner, and these publications are recommended to any who wish further information on this subject.

Leaf spot. Spotting of the leaves is closely associated with the russetting of the fruit by spray. However, a study of this trouble extending over several years and representing material collected in many different parts of the State shows that leaf-spot in Maine is by no means confined to that caused by the use of sprays. In 1908 leaf-spot was exceedingly abundant on unsprayed trees all over the State. As is stated elsewhere in this bulletin (p. 359) various fungi were found in these spots on leaves from sprayed and unsprayed trees, but of these *Sphacropsis malorum* Pk. was the only one which was capable of causing the disease on inoculation from pure cultures.

While in some instances the spots caused by sprays did not appear quite identical with those caused by the fungus, these differences were not constant enough to enable one to distinguish one from the other with any degree of accuracy. Moreover old spots made by sprays were usually attacked by fungi so that it is only by knowing the history of the case and noting the relative amount of spotting of leaves on sprayed and unsprayed trees under like conditions that one is able to judge whether the spotting is caused by sprays or fungi. Fig. 240 illustrates spotting caused by spraying and Fig. 241 spotting caused by *Sphacropsis malorum*.

The first indication of the formation of a leaf spot is the appearance of minute specks on the leaves where the healthy green has changed to a reddish or purplish color. Soon these change to larger, dead, brown spots, usually quite sharply defined against the adjoining green, though in severe cases of spray injury the whole leaf begins to turn yellow and soon drops off, resulting in many instances in partial defoliation. As a rule the spots are round, or oval and quite regular, but they may be of various shapes and sizes.

It has been claimed that lime-sulphur sprays do not cause leaf-spot. The experiments already referred to (p. 346) which were conducted by Mr. Bonns in 1910 with lime-sulphur and similar substitutes for bordeaux mixture used with lead arsenate as an insecticide, indicate that exceptions to this statement may be expected when these sprays are tried on the more tender varieties like the Ben Davis.

Experiments conducted at Orono by the writers in 1908 and 1909 with self-boiled lime-sulphur in comparison with bordeaux mixture on Milding, Fameuse and McIntosh resulted in no injury with either spray. Moreover published reports of spraying apple trees in Arkansas, Oregon, Missouri, New York and New Hampshire, with self-boiled, home-cooked and certain of the commercial lime-sulphur sprays are agreed as to the absence of spray injury from lime-sulphur. However, in our own experiments and in some of the others mentioned the trees used were not those which are particularly susceptible to bordeaux injury, and while the results are of value as showing the fungicidal value of lime-sulphur, they do not show that it would not produce spray injury on the more tender varieties. Much more experimentation will be necessary to determine this point; hence it is impossible at this time to state with any degree of accuracy what may be expected from the lime-sulphur sprays in the line of spray injury. However, there is every reason to believe that it may be used on the more tender varieties with much less danger of injury than with bordeaux mixture. It is probable that the combined use of the two would yield the more satisfactory results. That is, for the more tender varieties, use bordeaux mixture for the first spraying, in the spring before the leaves unfold, followed with lime-sulphur for the later sprayings.

Baldwin spot. The disease which is generally known in Maine under this name is not of fungus origin. It takes its name from the fact that it was first observed on and occurs most commonly on Baldwin apples, but it is not confined to that variety.

This disease is characterized by sunken spots distributed irregularly over the surface of the apple, as shown in Fig. 242. These spots are somewhat hemispherical in shape. They vary in size from one-eighth to one-fourth inch in diameter and have very much the appearance of bruises. An examination of the tissues

beneath shows that they are brown in color and have become somewhat dry and spongy. In some cases the Baldwin spot appears on apples as they are ripening but in other cases it develops in storage. It may be confined to individual trees in an orchard or to certain branches of a tree.

In late stages the tissues beneath the spots become shrunk so that the pitting is deeper. The brown coloring is not confined to the region just beneath the spot but is found also in the tissues surrounding the vascular bundles in later stages.

This disease should not be confused with the spot of apples caused by the fungus *Cylindrosporium pomi* Brooks, see page 356. The fungous disease can be controlled by spraying but the Baldwin spot cannot be controlled by that means. The writers believe that confusion of these two spots of apples in the past is responsible for reports which have been made of the control of Baldwin spot by spraying. The cause of the trouble is not well understood and until this is known little can be done toward finding methods of prevention.

In many of the earlier descriptions, spots on apples caused by the fungus were confused with spots which are not caused by a fungus and a composite description was made. In New Hampshire Experiment Station Report 20, p. 342, Brooks says: "It would be difficult to decide from the earlier descriptions given in the bulletins of the New Hampshire Station whether the Fruit Spot or the Fruit Pit (the original Baldwin spot) was under special observation. The descriptions are better if taken as applying to the two diseases than if considered as applying to either to the exclusion of the other. The spraying experiments were undoubtedly made upon the Fruit Spot. So far as the writer has been able to learn, a distinction between these two diseases has never been made."

The fact that the two diseases were sometimes confused and considered as one before the time of Brooks' publication together with the name which he has applied to the fungous disease has led a number of people to conclude, without careful study of the distinction which he has made, that all of the spotting of Baldwin apples is due to the fungus *Cylindrosporium pomi*.

The observations of the writers have convinced them that the Baldwin spot is of common occurrence in Maine, and that apples affected by this disease are more seriously injured than are Baldwin apples affected by the fungous disease.

Hail injury. During the past 2 or 3 years different parts of the State have experienced hail storms of sufficient severity as to badly injure the young fruit on the apple trees. There is nothing which can be done to prevent this injury, but frequently it is not noticed at the time and is later attributed to fungi, insects or other causes. The fruits may be badly deformed and scarred resembling somewhat curculio injury but the characteristic crescent shaped scars of the latter are not present. Quite frequently hail injury is followed by fungous decays of the fruit resulting from infections of the wounds.

Stag horn. Very frequently apple trees are seen with the topmost branches dead and remaining as dry sticks like antlers projecting above the foliage. This condition may be due to various unfavorable conditions, but in Maine it is chiefly encountered with old trees which have long remained unsprayed, unpruned, uncultivated and unfertilized. This allows opportunity for wood destroying fungi to gain an entrance. Once started their growth will eventually destroy the whole tree. Severe heading back and clearing out of the dead and fungus infested wood followed by cultivation and fertilization should be resorted to. In some instances it may be necessary to top-graft to renew the head of the tree. The full results of such treatment do not show the first year. Great care should be taken not to leave wounds through which the spores of fungi can gain an entrance to cause future decay.

Lichens on apple trees. Not infrequently complaints are received, particularly from coast towns, with regard to fruit trees being over-run by lichens, sometimes improperly called "mosses" by orchardists. While mosses are not uncommon on old, neglected fruit trees, lichens are much more frequent. The latter are foliaceous growths of various colors, the more common being grayish and found indiscriminately upon trunks of trees, rocks, old fence boards, etc. Quite frequently these lichens are found in large numbers upon orchard trees—apples, pears and plums—particularly so in the states farther south. Fig. 244 represents a portion of a branch from a neglected Maine apple tree. A large proportion of the branches were covered with lichens as shown in the illustration.

In temperate climates lichens occurring on tree trunks are not considered to be parasitic. In the tropics there is evidence that

one or more kinds are probably parasitic. However, all are agreed that lichens are decidedly objectionable on fruit trees. They harbor insects and fungi, tend to keep the branches moist and more likely to decay, besides being untidy and unsightly. While they may not secure any nourishment from the trees they certainly must interfere seriously with the functions of the bark on the younger limbs.

Two or 3 pounds of copper sulphate to 50 gallons of water or a 5-5-50 bordeaux sprayed on the trees before the buds swell in the spring will generally destroy the lichens. A wash such as is used for borers consisting of one pound of potash or concentrated lye to 5 gallons of water, put on with a brush, is said to be effective. *None of these materials should be sprayed on the trees when in leaf on account of injuring the foliage.* Thorough spraying with 3-3-50 bordeaux in the spring and early summer, as recommended for apple scab and other fungous diseases, would doubtless do much to hold the lichens in check, if not destroy them altogether. Hence, if the orchard is well cared for and sprayed it will not be infested with lichens.

PARASITIC DISEASES.

DISEASES OF THE FOLIAGE AND FRUIT.

Scab. Probably no other disease of the apple is of so much economic importance to Maine orcharding as the common apple scab caused by the fungus *Venturia pomi* (Fr.) Wint. The losses from this disease are not so much in the destruction of the fruit as in the lowering of its market value. On account of the attacks of this one disease, which is largely preventable, the financial returns from the orchards of many sections of the country are reduced from 25 to 50 per cent yearly.* Were it properly controlled in Maine a large proportion of the crop of some varieties which now goes as No. 2 and No. 3, might be marketed with the No. 1 grade. Moreover where spraying operations have not been generally practiced the importance of this fungus is in no way realized. For years it has been common and widespread, particularly on certain varieties and the orchardist has learned to regard it as one of the things to be

* Duggar, B. M. Fungous Diseases of Plants. p. 265, 1909.

expected and not as something which can and should be prevented.

The apple scab fungus may attack the flowers, twigs, leaf-stalks, leaves and fruit but it is upon the last two that its appearance is most prominent. While severe attacks on the leaves do much to weaken the trees, often causing considerable defoliation, the direct monetary loss to the orchardist is greatest from the effects of fruit injury for the reasons mentioned above.

Scab appears on the leaves in the form of a superficial, somewhat velvety, olive-colored growth, darker than the leaf green.* This growth is more likely to be observed on the under side of the leaf but both sides may be attacked. It may occur in spots but is frequently more abundant along the line of the mid-rib and large veins. The later stages may be compact, thin-scurfy, or more frequently especially if viewed with a magnifying glass of low power it will be seen to be ramifying and much branched giving a beautiful, delicate, "moss agate" effect. Badly attacked leaves may be more or less curled and crinkled and where defoliation occurs a pronounced yellowing may appear. Fig. 247 shows the characteristic appearance of a well developed leaf attack where the spots have run together along the veins.

Scab on apple leaves was very abundant in Maine during the summer of 1910 and samples showing the disease were received by the Experiment Station repeatedly from all of the apple growing sections of the State. Cool, moist weather either in the spring or summer favors the development and distribution of scab, while hot, dry winds and sunny days tend to keep it in check.

Two forms of spores are produced on apple leaves. If some of the olive-colored growth from the living leaves where the fungus is growing parasitically is scraped off and examined under the microscope a large number of the summer stage spores are found. These, and like spores produced on the fruit spots, are responsible for the summer spread of the disease. In the winter the fungus develops saprophytically in the fallen leaves under the trees and there produces an entirely different type of spore. While the summer spores can live for some time and doubtless it is not impossible for them to remain alive over win-

* Before the spores begin to form the affected areas are of a lighter green than the healthy parts of the leaf.

ter especially on fruit left on the trees or on the ground it is probable that much of the spring infection comes from the winter spores formed on the fallen leaves. It is a matter of common experience that the lower leaves on the tree are the first to show attacks of scab in the spring. Hence raking and burning the leaves would do much to lessen the danger of infection. The formation of winter spores takes place more readily when the leaves fall on sod or are partly covered by grass, other leaves, etc. Orchard cultivation produces conditions unfavorable to the propagation of scab spores and early spring plowing buries many of them where they will decay and do no damage.

Scab on the fruit is too familiar to need much description. It first appears as small, circular, olive-colored spots on the skin of the apple, these later enlarge, many of them becoming one-fourth of an inch or more in diameter, roundish, roughish and dark olive-colored, usually surrounded by a light gray border. Several spots may coalesce and form irregular patches, sometimes covering a large portion of the apple. In severe attacks, especially those resulting from early infections when the fruit is small, the apples often become cracked and badly distorted in shape due to the unequal growth of the healthy and diseased portions. Fig. 245 represents an apple in this condition.

While scab on the fruit is largely a superficial growth, the injury it does directly and indirectly is by no means confined to simple damaging of the appearance of the fruit. As is pointed out elsewhere in this publication (p. 34) epidemics of pink rot and some of the blue mold decay come from secondary infections of these fungi through scab spots. Scabby apples in addition to being more likely to decay wither more rapidly in storage than do perfect apples.

In a former publication of this Station attention was called to what then appeared to be a rather novel and uncommon form of the development of scab on apple fruit—its appearance and growth on apples in storage cellars.* Since the publication of this article certain more or less general statements have been found in the early Station literature indicating that somewhat the same thing had been noted and recorded at least 20 years

* Morse, W. J. Me. Exp. Sta. Bul. 164, p. 4, 1909.

before.* From information collected since publishing the account above referred to, it would seem that the appearance and spread of apple scab in storage is by no means uncommon in eastern States but in the past it has been largely overlooked.

Apple scab in storage may develop on fruit which, when placed in the cellar, appeared entirely free from the disease. It differs in appearance from the spots formed out-of-doors so much that at first one is doubtful as to the identity of the two diseases. Cultures made from the storage developed spots settled this point beyond doubt. Instead of soon breaking out and producing olive-colored summer spores the fungus usually remains beneath the unruptured cuticle, and the diseased portions appear as slightly sunken, small, black, somewhat shiny spots. As observed in Maine these storage developed spots have always been much smaller than those produced out-of-doors. Many of them are only of pin-head size. Brooks, however, has shown that they may attain a much larger size.** Fig. 246 shows the characteristic development of apple scab in storage. Doubtless much of the infection takes place immediately before or at the time of picking, but in one instance, at least, observed during the past winter, the evidence plainly indicated spread in storage. In a box of very clean No. 1 McIntosh, packed for perfect apples, one bearing a medium sized scab spot covered with spores was placed by accident. This box was placed in a relatively cool but quite moist cellar and when opened by one of us in mid-winter several apples lying immediately below the summer-scabbed apple were covered with the small black spots above described. The remainder of the fruit in the box was without blemish of any kind

Directions for the control of apple scab by spraying will be found on p. 390. Fruit from trees that are well sprayed will be less likely to develop the disease in storage. Scabby apples should be carefully sorted from the sound before storing. The temperature of storage should be as low as consistent with safety and not subject to abrupt changes. Very moist storage conditions should be avoided.

* Garman, H. Ky. Exp. Sta. Rep. 2, p. 48, 1889.

McCarthy, Gerald. N. C. Exp. Sta. Bul. 92, p. 88, 1893.

Henderson, L. F. Idaho Exp. Sta. Bul. 20, p. 83, 1899.

** Brooks, Chas. N. H. Exp. Sta. Bul. 144, p. 113, 1909.

Cylindrosporium fruit spot. This spot of apples which was first described by Brooks* is caused by a fungus, *Cylindrosporium pomi* Brooks. It should not be confused with the disease of apples which has been known for several years as Baldwin spot and which has been studied by a number of investigators. The Baldwin spot is not caused by the growth of a living organism, as has been proved a number of times by men working in widely separated places.

In Brooks' paper he has distinguished very clearly between the two diseases, but the writers regard it as unfortunate that he has substituted the name "Fruit Pit" for a disease which has been generally known in other parts of New England under the name "Baldwin spot." because certain writers and others have erroneously used the term "Baldwin spot" so as to include an entirely distinct disease. It is freely admitted, however, that if no confusion would result and the disease were being described for the first time, "Fruit Pit" is a more accurate descriptive term. In a recent text-book on plant diseases, the *Cylindrosporium* disease has been indexed as "Baldwin Fruit Spot" and this leads to more or less confusion. The writers have heard the opinion expressed a number of times that the cause of Baldwin spot was explained by Brooks' study of this fungus. They wish simply to assist in making clear the fact that Brooks recognized and described two distinct diseases and that the disease caused by *Cylindrosporium pomi* is not the same as the well known Baldwin spot, the characters and occurrence of which were so well pointed out by Jones.** Unfortunately in Jones' account of Baldwin spot he includes the results of Lamson's apparent control of the disease by spraying with bordeaux mixture. Brooks shows, however, that there is every reason to believe that Lamson's results were really from the control of the *Cylindrosporium* fruit spot which he confused with the true Baldwin spot.

The *Cylindrosporium* fruit spot occurs on a number of varieties of apples, and the writers are convinced by their observations that it does much more damage to some other varieties like the Bellflower in Maine than it does to the Baldwin.

* Brooks, Charles. The Fruit Spot of Apples. N. H. Exp. Sta. Report 20: 332-365. 1908.

** Jones, L. R. Vt. Exp. Sta. Rep. 12, p. 161. 1899.

According to Brooks, the *Cylindrosporium* disease appears first about the middle of August. (The true Baldwin spot does not appear till nearly harvest time or in storage). When it first appears one notices spots of deeper red on the darker colored portions and darker green on the lighter portions of the surfaces of affected apples. At this stage they are but slightly sunken, if at all, and there is no suggestion of a bruise. From Brooks' studies it appears that the fungous spots on red surfaces become more sunken later in the season, the color gradually changes from brown to black, and in cellar storage the red spots become badly browned and sunken. The green spots may take a similar course but in many cases there is no marked change in their surface appearance. However, according to the experience of the writers, the spots caused by the fungus are not as a rule so large and do not produce such deep pits in the surface as are characteristic of later stages of the non-parasitic trouble. Also on the lighter skinned apples there is not so much danger of confusing the two troubles when one once has the characters of each clearly in mind.

On yellow-skinned apples like the Bellflower the spots are very conspicuous at harvest time. They are of a bright carmine, the older and larger having a darker, brownish center, with seldom any pitting even after some time in storage. The disease is of almost universal occurrence in Maine on this variety—so much so that some apple growers have come to regard the *Cylindrosporium* spots as a natural marking of the variety and frequently exhibit such apples for prizes at fairs and pomological meetings.*

The superficial appearance of apples of the Bellflower variety which are affected with the *Cylindrosporium* disease is quite distinct from that produced by the true Baldwin spot on other varieties as will be seen on comparison of Figs. 242 and 243.

Brooks has made a careful study of the control of the *Cylindrosporium* fruit spot in New Hampshire. He found that infection of the apples takes place in July and that the spots make their appearance in August. He found that either bordeaux

* Following the methods by which the fungus was originally isolated, i. e., by transferring pieces of the browned tissue to tubes of sterile, distilled water, it has been obtained from these spots a sufficient number of times to show its constant association with them.

mixture or lime-sulphur gave good results in the control of the spot if applied at the same time or a little later than for the control of apple scab.

This disease is of common occurrence in Maine and it does considerable damage by injuring the appearance of fruit. Fruit growers should become familiar with the disease and make efforts to prevent the loss which it causes by reducing the price which they receive for their apples.

Sooty blotch and fly speck of the fruit. These diseases take their names from the appearance which the growth of the fungus gives to the fruit. Both are now regarded by various writers as caused by the same fungus, *L. blotchyum* (Fr.) Sacc. The fungus does not penetrate into the apple. In the case of sooty blotch, the mycelium spreads over the surface, covering areas which vary in size and sometimes completely the whole apple is covered in bad attacks. Fig. 29 is a photograph of an apple affected with sooty blotch. Fly speck is characterized by the development of black, dot-like, conical or fungous threads closely woven together which occur in patches on the surface of the apple.

The chief loss caused by these diseases is in injuring the appearance of fruit and thus by lowering its market value. Neither sooty blotch nor fly speck is of so common occurrence in Maine as they are farther south. Where thorough spraying is done, these diseases are effectually controlled.

Sphacopsis leaf spot. Leaf spot is a common and widely distributed disease of the apple in Maine. With some varieties and under certain weather conditions a spotting of the leaves is caused by spray injury, see p. 348. It is a matter of common observation, however, that orchards or trees which have never been sprayed are often affected with a spotting of the leaves which in some cases is quite serious.

Affected leaves show little spots of dead tissue, usually somewhat circular in outline. The dead portion is not quite so thick as the surrounding green tissue and takes on a brown color. On the dead spots little black bodies are frequently found which are the fruiting portions of the fungi associated with the spots. The dead spots often show concentric rings.

* Duggar, B. M. Fungous Diseases of Plants. p. 367. 1900.

Leaf spot of the apple has been discussed by a large number of writers and the cause attributed to a number of different fungi. In many cases the fact that a certain fungus was very frequently found on the spots was taken as sufficient evidence that it was the cause of the disease. Of recent years it has been questioned whether the presence of a fungus on a leaf spot, no matter how constantly it occurred there, should be taken as evidence that the fungus caused the disease. It has been held that it is necessary to isolate the fungus in pure culture and then produce the disease by inoculation under control conditions before the matter could be definitely settled. In the summers of 1906 and 1907 Scott and Rorer* made a study of the disease in the Ozarks in which they isolated fungi from leaf spots and carried on inoculation experiments. Of the various fungi isolated *Sphacropsis malorum* Pk., the same fungus which causes a destructive fruit rot (p. 362) and limb canker (p. 372) in Maine was the only one capable of causing the disease when its spores were sprayed on the leaves.

On account of the importance of the fungous leaf spot in Maine it was thought desirable to make a thorough study of the pathogenicity and interrelation of the various fungi found associated with leaf spot, fruit decays, and limb cankers in this State. The results of a part of this work have already been published** and other parts will be published later. It is sufficient for our present purpose to state that out of a large number of fungi isolated from leaf spot in Maine *Sphacropsis malorum* was the only one which would produce the disease on inoculation.

The results obtained here, taken together with the conclusions of Scott and Rorer and the work of Lewis† in New Hampshire would seem to indicate that *Sphacropsis* is the only one of the fungi occurring so abundantly on the dead spots in apple leaves which is capable of causing the disease in this section of the country.

* Scott, W. M., and Rorer, J. B., Bureau Pl. Ind., U. S. D. A., Bul. 121, Part V, pp. 47-54, 1908.

** Lewis, C. E. Apple Diseases Caused by *Coryneum foliicolum* and *Phoma mali*. Me. Exp. Sta. Bul. 170, 1909. A New Species of *Endomyces* from Decaying Apple. Me. Exp. Sta. Bul. 178, 1910.

† Lewis, Isaac M., N. H. Exp. Sta. Rep. 20, pp. 355-359, 1908.

This fungous leaf spot causes a considerable amount of loss in Maine orchards and this loss is not always realized by the apple growers. The dead spots in the leaves interfere with their function, and, in addition to this, large numbers of the diseased leaves fall prematurely, thus seriously interfering with the nutrition of the trees.

As has already been mentioned the fungus causes the canker of the wood and the black rot of the fruit, therefore preventative measures must be directed toward all 3 forms of the disease. Since inoculation experiments indicate that in Maine infection must take place before the middle of July spraying as recommended for apple scab would do much to control the disease. This should be supplemented with the removal and destruction of limb cankers and decayed fruit.

From their observations the writers are convinced that leaves of trees which are well fertilized, cultivated and generally well cared for are not so susceptible to the disease as the leaves of neglected trees. It must be borne in mind, however, that a similar spotting of the leaves of susceptible varieties may occur as the result of spray injury.

Rust. This disease of apple leaves and fruit which does great damage in some apple growing districts does not seem, according to the observations of the writers, to be of very common occurrence in Maine. The fungi* which cause this trouble pass a part of their life upon the apple and related plants and a part upon the red cedar where they cause the abnormal development of small brown knots on the twigs which are known as "cedar apples." In the spring these knots produce thread-like tubes which when wet with rain swell up, become gelatinous, are orange-yellow in color, and throw off large quantities of spores. These spores are capable of infecting apple leaves and are produced when the latter are young and most susceptible to infection.

On the apple leaf there is first a thickening of the tissues in small spots at the points of infection. Later in the season these thickened places become ruptured on the under side and short.

* Apple rust may be produced by *Gymnosporangium macrocarpum* Lk. or *G. globosum* Farl. It is not known which species is responsible for the rust in Maine but probably it is the latter. The red cedar, *Juniperus virginiana* L. is the alternate host for both.

thread-like growths project beyond the broken epidermis. Orange-colored spores are formed in these places. It is on the leaves and fruit of the apple that the injuries caused by this rust become of economic importance. Spraying has not been very successful in controlling this disease. Where the rust appears, the removal of red cedars from the neighborhood of apple orchards is recommended.

Powdery mildew. The common name for this trouble comes from the appearance of the affected leaves which is shown in Fig. 248. The fungus, *Podosphaera oxycanthae* (DeC.) DeBary, grows upon both surfaces of the leaf but does not penetrate the tissues, except to throw in short feeding branches. During the summer many spores are formed and it is the masses of spores which give the white powdery appearance. The parasite spreads rapidly by means of these summer spores. Later in the season another stage of the fungus develops on the diseased leaves and this is indicated by the presence of small but plainly visible, spherical, black bodies which are scattered here and there among the white mycelium. Spores are produced in these bodies which carry the fungus over winter.

On the apple, the chief damage done by this fungus is in its attacks upon nursery stock where it causes considerable loss. Spraying with diluted lime-sulphur should go far toward controlling this disease.

FRUIT DECAYS.

During the past 3 years this laboratory has devoted considerable attention to a study of the fungi which cause decay of apples in Maine. Fungi have been isolated from decaying apples from various places and these have been tested by means of inoculations in order to determine the extent to which each was capable of causing decay. It has been found that Maine has a considerable number of the apple decay fungi which have been described from other places but the relative amount of rot caused by some of these fungi under local conditions differs materially from the amount attributed to the same fungi in other parts of the United States. For example the "bitter rot" fungus while it occurs here does very little damage in comparison with the amount of loss resulting from its attacks in other sections. The apple decays which have been found in Maine will be described

in the following pages together with the means of control so far as these measures are understood.

Black rot. This rot is caused by *Sphacelopsis malorum* Fr. which also causes a decay of pear and quince. The fungus attacks apples both on the tree and in storage and is responsible for much of the rot on the trees in this State. It is rapide of causing decay of green fruit but its progress is much more rapid in apples which are ripe or nearly ripe. Early apples are especially susceptible. As a cause of storage decay, *Sphacelopsis* probably ranks second to *Penicillium* which is described below. On account of the relation to leaf-spot and limb cankers as well, the black rot fungus in distribution and economic importance probably ranks second in the State to that which causes apple scab.

Black rot of the apple takes its name from the appearance of the fruit in the late stages of the decay. In early stages, the decayed region is brown in color but the mycelium of the fungus takes on a dark color with age and thus colors the apple. The fungus usually enters the apple at either the blossom or stem end and, if the temperature is favorable, for general, spreads rapidly and causes the complete decay. The decaying region is marked by concentric rings. When the mycelium has grown in the apple for a sufficient length of time the threads begin to form little aggregations just beneath the epidermis which develop into the small black bodies which later break through the cuticulus. The spores of the fungus are formed inside these bodies and escape through an opening at the apex. The appearance of an apple in this stage of the decay is shown in Fig. 250. There is only one other fungus (*Phoma mali*, see p 365) which in Maine causes a similar appearance of decayed apples and the amount of loss caused by that fungus is small as compared with the loss caused by *Sphacelopsis*.

Since the fungus which causes the black rot of apples also causes a disease of the wood and leaves, any means of control of the rot must take into consideration these sources of infection of the fruit. Old, diseased trees are almost certain to produce *Sphaeria* spores in large numbers on dead and dying limbs and these spores are ready to infect the apples as they mature and to cause their decay. One good means of control then is to remove the source of infection by putting out and burning all

dead and diseased wood. All decayed fruit should also be destroyed. If this is followed by the spraying which is recommended for apple scab it will go far toward the control of this disease.

Penicillium or blue mold decay. This is the rot of apples which is caused by the common blue mold which is familiar to every one on preserved fruits, jellies, etc. Blue mold grows as a saprophyte on a large number of dead organic substances and produces large numbers of spores so that the spores are practically everywhere present and may start a new growth of the mold whenever they fall upon a substance which furnishes a suitable food supply provided that the temperature is favorable for growth. It is a widespread cause of decay in Maine, especially where the fruit has not been carefully handled.

This decay of apples is probably caused by more than one species of this genus. In some cases other fungi aid in the decay but since *Penicillium* breaks out and shows more prominently on the surface of the apple, it is often held responsible for more of the decay than it causes. There can be no doubt, however, that one or more species of *Penicillium* cause a large amount of the soft rot of stored apples. This is primarily a rot of ripe apples and does not cause decay of green fruit. The threads of the fungus cannot penetrate the uninjured epidermis of the apple but must gain entrance through injured places such as bruises, cuts, cracks, worm holes, spray injured places or scab spots. It spreads rapidly in ripe apples and complete decay takes place in one to two weeks. The tissues become soft and are light brown in color. Little tufts of mycelium which bear the spores break out on the surface of the decayed region as shown in Fig. 251. These tufts soon become light blue or blue-green, later gray-green to brownish in color. Apples rotted by *Penicillium* take on a characteristic moldy odor and taste.

Since the fungus enters the apple through wounds, any means of control of the rot must look to the prevention of injuries to the epidermis. Care must be taken to produce good, sound apples and then these should be picked and handled in such a way as to avoid cuts and bruises. The apples should be stored where the temperatures are as low as can be maintained with safety from freezing.

Bitter rot. This disease which does so much damage in some

apple growing regions is caused by *Glomorcella rufomaculans* (Berk.) Sp. & von Sch., and is found occasionally in Maine, but its occurrence is so rare that it is not necessary to recommend special means for its control. Moreover it does not seem that bitter rot will do great damage under Maine climatic conditions if the recommendations with regard to the removal of cankers and spraying are followed as are given for the black rot fungus. Where bitter rot is prevalent spraying later in the season is necessary. Fig. 252 shows the appearance of this rot. The fungus found here differs in certain characteristics from the form described from farther south and there is some evidence from our inoculations that it is not so actively parasitic.

Brown rot. The brown rot of the apple is caused by *Sclerotinia fructigena* (Pers.) Schroet., the same fungus which causes the destructive brown rot of peaches and plums. This decay of apples occurs to some extent in Maine and in some cases may do considerable damage. The fungus spreads through the apple rapidly and in the early stages the surface of the decayed region is smooth and brown. Later little tufts of fungus threads break out on the surface of the apple and these produce the spores as shown in Fig. 253. Often when this rot takes place in storage, away from the light, the tufts of spores do not break out on the surface and the skin assumes a shiny black color. The apples become shrunken and wrinkled as they dry and in some cases these mummied apples hang on the trees over winter. It is these mummied apples which carry the fungus over from one year to another and for that reason all decayed fruit both on the trees and on the ground should be destroyed. The spraying for apple scab will also help to control this fungus.

Pink rot. In some seasons, especially when it is warm and wet at the time of harvesting, scabby apples are attacked by a fungus, *Cephalothecium roseum* Cila., Fig. 254. This is called pink rot on account of the appearance of the spots where the fungus grows out to produce its spores. The fungus, usually a saprophyte, occurs on a large number of dead parts of plants. Therefore, the material for the infection of apples is present whenever the conditions are favorable for the growth of this fungus. The fungus is unable to penetrate the uninjured epidermis of the apple and scab spots afford the chief means of entrance. To avoid loss from pink rot it is necessary to produce apples which are free from scab.

Alternaria decay. A decay of apples caused by a species of *Alternaria* was first described from Colorado by Longyear.* This fungus entered the apple at the blossom end and produced a cob-webby growth of mycelium around the seeds. An *Alternaria* has been found a number of times associated with apple decays in Maine. This fungus usually occurs on injured places such as the blossom end injured by insects or broken places in the skin. Associated with other fungi this *Alternaria* forms a rather thick, dry covering of mycelium over the injured place. The fungus does not usually penetrate very deeply in such cases but when ripe apples are inoculated from pure cultures, it is found to be capable of causing a complete decay. This fungus alone has been reisolated a number of times from decaying apples which had been inoculated, thus proving that it caused the decay. The apple decay *Alternaria* differs sufficiently from a species of the same genus which has been found repeatedly on dead spots in apple leaves and on dead parts of other plants so that the two fungi can be distinguished readily in culture. The *Alternaria* from apple leaves has not been found to cause decay of the fruit upon inoculation.

Botrytis decay. A species of *Botrytis* causes a part of the decay of apples in Maine. It has been found causing a rot of early apples on the tree and inoculations have shown that it not only attacks ripe fruit but that it is capable of causing a rot of green apples. The fungus spread, rather rapidly in the tissues of winter apples which were inoculated early in August so that in 2 weeks one-half of each apple was decayed. It causes a rapid and complete decay of ripe apples.

Phoma decay. This rot is caused by *Phoma mali* Schulz & Sacc., which is able to attack both wood and fruit. A more extended account of this fungus is given in Bulletin 170 of this Station. It causes only a slight decay of green apples but when ripe apples are inoculated the rot spreads almost as rapidly as in the case of some of the well known apple destroying fungi. When the fruit is thoroughly invaded the pycnidia break out on the surface giving somewhat the same appearance as in the case of black rot but there is usually considerable mycelium on the surface of the apple and this is white in color. The appearance of an apple 34 days after inoculation with *Phoma mali* from a

* Longyear, B. O. Col. Exp. Sta. Bul. 195, 1905.

pure culture is illustrated in Fig. 235. The fungus was reisolated in pure culture from this apple.

Hypochnus decay. Eustace* has described a decay of apples in New York caused by a species of *Hypochnus*. A fungus which agrees in certain characteristics with the one described by Eustace has been found here associated with a surface spotting or pitting somewhat like the Baldwin spot and *Cylindrosporium* troubles of apples. The fungus which we have had in culture for 3 years has never fruited, although it has been grown on a variety of culture media and so it is impossible to state positively that it is the same fungus which Eustace studied but it has the same kind of clamp connections of the cells of the mycelium and the fungus agrees in appearance with his description. Inoculations with this fungus caused only a small sunken spot of decayed tissue at the point of inoculation.

Fusarium decay. The examination of decaying apples from a large number of sources has frequently shown the presence of *Fusarium* spores. In some cases *Fusarium* has been found fruiting on the surface of decayed fruit, the rather thick masses of spores giving a pink color, in other cases the mycelium has been found in the cavity around the seeds sometimes destroying the seeds. In the seed cavity it is either white or reddish in color. The spores are produced in considerable numbers on this mycelium. *Fusarium* is sometimes found associated with other fungi forming a thick felt-like growth over injured places on the surface of apples. From such a growth on one apple one of us (L.) has isolated 8 different fungi, 4 of which, including one species of *Fusarium*, caused complete decay of ripe apples from inoculation from pure cultures. In advanced stages of *Fusarium* decay, white mycelium breaks out on the surface of the apple as shown in Fig. 250. A study is being made of the apple decays caused by species of *Fusarium* and a detailed account will be published soon in a bulletin of this Station. A *Fusarium* decay has been described from Europe by Osterwaller,† but so far as the writers are aware no such decay has been reported in America. In this investigation 3 forms of *Fusarium* have been

* Eustace, H. J., N. Y. State Sta. Bul. 235, pp. 123-129. 1903.

† Osterwaller, A. Ueber eine bisher unbekannte Art der Kernschalenfaule, verursacht durch *Fusarium putrefaciens* N. sp. Centr. Bakt. Zweite Abt. 13. 207-213; 330-338. 1904.

isolated from decaying apples, and have been found to cause decay of both green and ripe apples. These have been grown in pure culture from one to two years and show such differences in cultural characteristics as to make it seem probable that they are different species. One of these bears considerable resemblance to *F. putrefaciens* Osterwalder, but does not seem to be identical. One of the others has been found to cause not only a decay of apples but to cause decay of parts of a number of other plants. Its occurrence on one of which at least practically insures the presence of spores of this fungus at the time when the infection of the apple would take place.

No special recommendations can be made for the control of these apple rots at this time. In a general way it may be said that the same methods which apply in the case of the well known apple decays will probably go far toward the prevention of loss from these fungi.

Verticillium decay. In 1908, a fungus was isolated from apples and tested by means of inoculations which, while it does not seem to be of very common occurrence, causes a distinct decay of both green and ripe apples on inoculation. This fungus spreads through the tissues of ripe apples at as rapid a rate as *Penicillium* but it produces a very different effect. The diseased portion is not soft but is rather hard and the affected apple keeps its normal shape for some time. The decayed tissue has an odor and taste which is characteristic and rather pleasant, not unlike that of dried cocoanut. Cultures of the fungus on prune agar give the same odor.

The causal fungus grows readily and spreads rapidly in plates of prune agar. It produces large quantities of spores. The masses of spores are white when young but become green with age. On the basis of the spores and of the manner in which they are borne in culture this fungus has been classified as a species of *Verticillium*. It is possible that this fungus, which is capable of causing a distinct decay, may be responsible for a part of the rot which is attributed to other fungi for when apples were inoculated with it, the fungus did not break out on the surface and produce spores.

Endomyces decay. In Bulletin 178 of this Station a new species of *Endomyces* is described which was found to cause a decay of ripe apples but which did not attack green fruit. This

fungus is of interest not so much on account of its economic importance, but because it represents a genus new to America.

Rhizopus decay. A soft rot of over-ripe apples is sometimes caused by black mold. This rot may be recognized by the fact that the mycelium which grows out over the surface of the affected apple is composed of thicker threads than are found in other apple decay fungi. If apples attacked by the black molds are kept in a warm, moist place the mycelium forms a thick growth on the surface. The spores are borne in little capsules on the ends of long stalks. When the spores are mature the whole mass becomes black in color.

The black molds are regarded as saprophytes as they are able to attack only ripe apples. They may cause considerable loss, however. To prevent this loss it is necessary to use the same precautions that are taken in the case of blue mold.

Other apple rots. In the course of the study of apple diseases, fruit has been inoculated with a number of other fungi isolated from wood, leaves, or fruit of the apple in order to determine whether these fungi are capable of causing decay. *Corynecum foliicolum* Fekl., and a species of *Cytospora* from diseased wood, produced a small amount of decay; *Coniothyrium pirina* (Sacc.) Sheldon, *Phyllosticta limitata* Pk., *Cladosporium herbarum* (Pers.) Link. and 3 undetermined species of *Aspergillus*, showed a little growth at the points of inoculation but did not spread to cause decay. One fungus which has been determined as *Dematium pullulans* DeBary has been found constantly associated with diseased apple tissues not only of the fruit but also of the leaves and wood. On account of the constant association of this fungus with apple rots, it was tested by means of inoculations but it did not cause decay. It may be possible, however, that when associated with other fungi the decay is hastened by its presence.

DISEASES OF THE WOOD.

Canker and Twig-blight. The term canker has become such a general one as not to admit of easy definition. It is commonly used to describe the condition of branches of trees in which an area of bark has been killed and has broken away so that a portion of the wood is laid bare or is covered only by cracked and roughened bark which does not protect the wood. In the

writers' opinion the term "canker" as applied to diseased areas on trees should be restricted to those characteristic lesions on the trunk and limbs which are the result of alternate attempts to heal, with the formation of new wood, followed by farther killing of the living tissue. In early stages of development, cankers show a region of sunken discolored bark and it is only in later stages that the bark breaks away. Cankers have been described as caused by frost, sun-scald, fungi, and bacteria. A considerable number of different fungi have been reported as causing canker of apple trees in different parts of the United States. These vary greatly in the amount of damage which they do in different regions. In some cases, a fungus which causes a great amount of injury to the trees of one region occurs rarely or not at all in another region.

The injury of apple trees through winter-killing is discussed on pages 341-344. Much of the disease of apple trees which Maine orchardists have been calling canker for the past 3 years had its origin in the severe winter of 1906-7. Some of the injuries resulting from that winter and the seasons following might possibly be properly classified under the term "frost canker." On the other hand, when whole trees were so badly injured that they died either that year or the year following, the injury was too wide-spread and acted too quickly to be regarded as canker. There are a number of forms of winter injury and the frost canker is only one of them. The frost canker is a local injury which tends to heal over under favorable conditions for growth unless the new growth is killed by another period of low temperature before it has become hardened. In this way the frost canker may spread, or in other cases the injured bark may serve as a place for the entrance of a parasite which may then spread in the bark and outer layers of wood and kill a rather large area in a single year.

So far as they have been investigated it has been found that the organisms which cause canker of fruit trees in Maine are, in a large measure, wound parasites. They are unable, as a rule, to penetrate the uninjured bark but must enter through wounds. In this sense, the places injured by freezing serve the same end as wounds of any other kind. However, it may be pointed out that cankers caused by fungi do not spread so rapidly as to kill trees in the short time which has been observed in the case of winter-

killed trees in this State. In the case of young trees the fungus may in some cases girdle the tree in a few weeks and thereby cause its death. The same holds true of small branches of old trees, but in the case of large branches the fungus usually spreads but a few inches each year forming true cankers, and the rough, blackened areas that are frequently seen on large branches often represent a development of several years. The living tissues attempt to heal over the wound by the formation of callus and in some cases with considerable success. Often the parasite ceases to spread in the bark when the dry season of summer comes on and a crack forms between the healthy and diseased bark. The following year the diseased area may continue to spread or the callus may check it considerably. Often other fungi, some of them saprophytes, grow upon the dead bark. Thus it may be seen that while fungi which enter through winter injuries may spread and ultimately do great damage to the tree, there is no reason to believe that the death of large trees which was observed in Maine orchards immediately following the winter of 1906-7 was due to a parasitic organism because the trees died in many cases in too short a time for their death to have been caused by such organisms. On the other hand, there were many places injured by that winter, which became infected by fungi. Where these have been neglected the diseased areas have spread from year to year and have done much damage, often developing into true cankers.

There are many other wounds than those caused by freezing through which parasitic fungi may enter. By this it is not meant that every wound that is made in the bark will necessarily become infected and develop into a diseased area. Frequently small wounds in the bark of young branches heal over quickly, without infection and no serious damage is done. In many cases, however, the spores of parasitic fungi are carried to wounds. This is especially liable to be the case when diseased branches are allowed to remain on the trees, or old neglected trees in the neighborhood produce abundant crops of fungus spores from year to year. Some of the ways in which wounds are made are: Barking of trunk and branches by machinery in cultivating and caring for the orchard; injuries by ladders and by men in picking fruit; branches are sometimes injured by props used to support a heavy load of fruit especially when they

are carelessly placed in position; in some cases hail-stones split the bark of small branches. Care should be taken to avoid any injury which is within the control of the orchardist. Wounds are sometimes kept from healing over by the woolly aphid which forms little cottony patches in wounds and by delaying the healing over process makes a favorable place for the entrance of a parasitic fungus.

Maine has only a few of the fungi which have been reported as causing canker in other parts of the country. Each section of the country seems to have one fungus which is responsible for a large part of the canker in that region. In this State, the fungus which causes the greatest damage is the black rot fungus, *Spacropsis malorum* Pk.; the bitter rot fungus occurs only very rarely in this region; *Myrosporum corticolum* Edgerton, is very common and apparently does some damage although it does not seem to be a very active parasite; *Coryneum foliicola* Fckl., and *Phoma mali* Schulz & Sacc., have been described in Bulletin 170 of this Station as causes of disease in this State; *Cytospora* sp. may cause some damage but it is not extensive. The European apple canker caused by *Nectria ditissima* Tul. and the blister canker, *Nummularia discreta* Tul., may be present in the State but they have not been observed.

Closely associated with canker caused by fungi is the killing back of small branches and twigs caused by the same organisms. In searching orchards in the State for cankers we have found this dying back of the branches and water-sprouts much the more common of the two. The fruiting bodies of the same fungi have been found on both, and cankers on larger limbs have been found repeatedly which apparently started from the disease following back on a smaller branch or twig. Inoculations with canker producing fungi early in the spring show that they are capable of killing the young twigs very rapidly and run back a considerable distance in a single season. A twig blight may be caused by the pear blight bacillus, but pear blight is rather uncommon in Maine. Moreover the entire absence of the characteristic "fire blight" has been noted repeatedly on pear trees growing within and alongside of apple orchards affected with the fungous twig blight.

In many ways the dying back of small branches is like the development of canker. The fungus may spread back only a

short distance each year for a number of years or, as indicated above, the spread is rapid and the branch is killed back a considerable distance in a single year. It is probable that in many instances the young wood is injured by freezing and the fungi gain entrance in this way.* We have observed the same thing where young nursery stock has become infected through wounds made in cutting back when set. Twigs and limbs affected in this way should be cut off well below the diseased portion and the wounds protected from farther infection.

Sphaeropsis canker. The canker caused by the black rot fungus, *Sphaeropsis malorum* Pk., is widely distributed in Maine. This disease is known as "The New York Apple-tree Canker," because it was first described from New York.** This fungus causes the black rot of the fruit and a leaf spot as well as the disease of the wood.

The appearance of different early stages of cankers caused by this fungus is shown in Figs. 257, 258 and 259. The dark colored, cracked bark of the older, central parts, some of the small, black pycnidia or spore bearing bodies, and the crack between the healthy and diseased bark are shown in Fig. 257. This also shows, somewhat indistinctly, where cracks have formed between the healthy and diseased bark at the end of each growing season for at least 3 years. In this and in Figs. 258 and 259 infection probably took place on a smaller twig or branch and followed back to the larger branch as suggested by the small, dead stubs. It is not always possible to see the extent of each season's growth on account of other fungi and lichens growing over the dead bark.

The fungus attacks either young or old branches and the amount of damage depends on the amount of bark and adjoining surface portions of the wood which is destroyed. In some cases a branch may be girdled in a short time and death of that branch results, but in other cases the canker spreads for years on one side of the branch before it is completely girdled. The other side of the branch in such a case may become somewhat enlarged.

To control this canker, the orchardist should remove all dead

* The manner in which young twigs and fruit-spurs become infected by fungi is a matter which needs farther investigation.

** Paddock, Wendell, N. Y. Exp. Sta. Bul. 163, 1899.

branches, and all old neglected trees such as one frequently sees along the roads and burn them. Branches which show bad cankers should be cut off back of the canker and burned. In the case of young cankers, the branch can frequently be saved by cutting away the diseased tissue down to healthy wood, disinfecting with a solution of copper sulphate, one ounce to one gallon of water, or corrosive sublimate, one part to 1000 of water, and then painting over with pure white lead in boiled linseed oil or coating with a good quality of grafting wax. The trees should be gone over carefully a number of times each year and developing cankers and wounds should receive attention. Spraying for apple scab will help to control the cankers by reducing the amount of material for infection and by covering wounds with the fungicide. All decayed fruit should be destroyed, since the black rot of the fruit and this canker are caused by the same fungus. The treatment outlined should go far toward controlling cankers caused by other fungi in this State.

Bitter rot canker. This canker caused by the fungus which causes bitter rot of the fruit is of rare occurrence in Maine. On the dead bark the fungus produces little black pustules from which, when they are mature, pinkish masses of spores exude. The spores from cankers cause much of the early infection of fruit on the tree each year. The appearance of the diseased bark of a young tree caused by inoculation with the bitter rot fungus is shown by Fig. 260.

Myxosporium canker. The fungus causing this disease has been much confused in the past with *Sphaeropsis malorum*. Edgerton's* study of the fungus has shown that the two are entirely distinct. This fungus is of very frequent occurrence in Maine, but its economic importance in this State is somewhat in doubt. So far as observed the damage which it does is confined to killing outer portions of the bark on old limbs and the killing back of the bark on younger limbs and twigs rather than to the production of true cankers. On such branches the fruiting pustules are found on the part which was first killed. The dead bark is separated from the healthy bark by a sharp line and is sunken as is shown in Fig. 261. The appearance of these

* Edgerton, C. W. Two little known Myxosporiums. *Annales Mycologici* VI: 47-52. 1908.

branches is very characteristic and they can be recognized by one who has become somewhat familiar with the various cankers and twig blights, without microscopic examination of the fungus. There is some reason to believe that the fungus is not a very active parasite and it may be possible that such diseased branches have been injuriously affected by some other agency before the attack of this fungus.*

Coryncum and Phoma cankers. In the examination of apple cankers the spores of *Coryncum folliculorum* and *Phoma mali* have been found of quite frequent occurrence. Inoculation experiments in 1909 proved that both of these fungi were capable of causing disease of healthy bark of apple branches. For a detailed account of the study of these fungi the reader is referred to Bulletin 170 of this Station. The appearance of different stages of *Coryncum* cankers is shown in Figs. 262 and 263.

Cytospora canker. A species of *Cytospora* has frequently been found on small branches which have been killed back but no true cankers have been seen. These lesions observed have much the same appearance as has been described for branches on which *Myrosporum* is found. After a little experience one can distinguish the two fungi on the bark without the aid of the microscope.

In Bulletin 191 of the New York Station it is suggested that a species of *Cytospora* found on diseased apple branches in that State is probably parasitic. The *Cytospora* which occurs on apple branches in Maine has been isolated, grown in pure culture where it fruits abundantly, and inoculations have been made in small branches in the orchard. The fungus made only a slight development in the injured tissue at the points of inoculation, while inoculations made the same day on the same branches with *Sphaeriaopsis* developed well marked cankers. The indications are that the species of *Cytospora* which is found in Maine is very slightly if at all parasitic.

Pear blight canker. The canker of apple trees caused by the pear blight organism, *Bacillus amylicarum* (Burrill) DeToni.

* The fungus has been isolated from such diseased branches and has been grown in this laboratory upon sterilized apple wood and bean pods for several months. Spores were produced in the cultures about one month after the fungus was transferred from plates to bean pod tubes. Some inoculations have been made and the results of these will be given in a later publication.

which has been reported as causing a great amount of damage in apple orchards in other states, has not been found in Maine, though careful search has been made for it. Almost none of the characteristic twig blight or "fire blight" on the pear which is a good indication of the presence of the organism has been seen. If this disease occurs on the apple in this State, it is of very rare occurrence.

Crown Gall. Apple trees, particularly nursery stock, sometimes have galls or knots which are usually located near the surface of the soil in the region of the collar. These galls are often covered with many fine roots giving them a hairy appearance. Such growths have been reported on a number of plants which are closely related to the apple and also on other plants which are not closely related.

In the earlier studies of this disease the cause was not understood. Injuries to the roots and unfavorable conditions of soil and moisture were advanced as causes of the trouble. Experiments were carried on in a number of places, however, which demonstrated that the disease is communicable. In 1900, Toumey* published an account of his studies of crown gall in which he reports the results of extensive inoculation experiments. He concludes that the disease is infectious and is caused by a slime mold. The nature of this organism made impossible the use of pure cultures in inoculations.

More recently Smith** and Townsend† have studied crown gall on a number of plants and they have been able to prove quite conclusively that at least a part of the crown gall of the apple is of bacterial origin, caused by the organism *Pseudomonas tumefaciens* Erw. Smith and Townsend.

The organism was first isolated from galls on the Paris daisy and inoculations showed that it could produce the disease. Inoculations of tomato, tobacco, potato, sugar beet, grape, carnation, raspberry, peach and apple were also followed by the development of galls. This led to the isolation of organisms

* Toumey, J. W. Ariz. Exp. Sta. Bul. 33: 1-64. 1900.

** Smith, Erwin F. and Townsend, C. O. A Plant Tumor of Bacterial Origin. Science, N. S. 25: 671-673. 1907.

† Townsend, C. O. A Bacterial Gall of the Daisy and Its Relation to Gall Formation in Other Plants. Science, N. S. (Abstract) 29: 273. 1909.

from the galls of peach, hard galls of apple, hairy root of apple, hops, rose, and chestnut, which were found to be very similar if not identical with the organism from the daisy.

The fact that crown gall of the apple is now definitely known to be caused by a parasite which also causes galls of a number of other plants is of great importance in the control of the disease. It will be readily seen that young apple trees should not be set in land on which another plant affected with this disease has been grown.

In the apple, the greatest amount of infection is likely to take place in nursery stock, as the trees are grown rather closely in the nursery row. When affected trees are set in the orchard, new galls develop from year to year and in many cases the trees weaken and die. Little good is accomplished by cutting off the galls at the time of setting the trees, as it is practically impossible to remove all of the infected tissue and new galls develop. It is best to secure apple trees from nurseries which are free from the disease, but in case diseased trees are received they should be destroyed. In the cultivation of orchards in which trees affected with this disease are known to occur, care should be taken that healthy trees do not become infected through injuries near the surface of the ground.

Wood destroying fungi. It is a well known fact that the heart wood of apple trees is often decayed. In many cases the extent to which the wood has been destroyed is not realized by the owner of a tree until it is blown over by a heavy wind and it is found that only a thin shell of sap wood remains. Such a condition is shown in Fig. 265.

It is not so generally understood by orchardists that this decay is caused by the growth of fungi. In some cases the mycelium of a fungus may grow on the interior of a tree for years before there is much evidence of its growth on the outside. Then after the mycelium has stored up a sufficient amount of food, the fungus produces its fruit. In many cases these wood destroyers belong to the bracket or shelf fungi of which a number of species have been reported on the apple. Very frequently the wood of apple trees is badly decayed before the fungus fruits and then it is too late to apply a remedy to the tree.

Wood destroying fungi enter the wood of trees through wounds which may be caused in various ways. Some of the

common ways are barking by machinery in cultivation and injuries by such animals as rabbits and mice, and by borers. Broken or improperly pruned branches make a good place for the entrance of fungi. A broken, splintered branch which will hold moisture makes an excellent place for the germination of spores and the mycelium after it has grown for a time under favorable conditions is able to penetrate the wood. Care should be taken to remove all such broken and splintered branches and in removing them long stubs should not be left which will be slow in healing over if they heal at all. In pruning the branch should be cut back as close to the larger branch or trunk as possible, and the surface of the wound should be parallel and as near as possible on line with the surface of the main trunk or branch. Such a wound if protected will heal over without injury to the tree, while even a short stub will never do this, although the wound made is much smaller. Much of the heart rot is caused by fungi which gain entrance through stubs left by improper pruning. When it is necessary to remove large branches, the wound should be painted or otherwise protected.

Wood destroying fungi may also enter the wood through places in the bark injured by canker fungi and by frost. Here again may be emphasized the necessity of attending promptly to the treatment of all wounds of whatever origin, as the control of wood destroying fungi must be a matter of prevention and not of cure.

ORCHARD SANITATION, SPRAYS AND SPRAYING.

From the foregoing pages it will be seen that all attempts at the control of fungus pests of the orchard must in a large degree be directed toward the application of preventative rather than curative measures. While spraying is beneficial and should be practiced by all, it should be supplemented by thorough orchard sanitation. No dead or diseased limbs, cankers, or mummified fruit should be allowed to remain on the trees or in the orchards. Particular attention should be given to the removal and destruction, by burning, of all rubbish, litter, decaying wood or fruit which might serve as breeding places for fungi or for insects. The good effects of cultivation in the orchard are by no means confined to those which tend to make available the food supplies contained in the soil and to the conservation of

moisture. It also assists materially in the control of the fungous and insect pests of the orchard, particularly the latter.

As has already been pointed out (p. 340), the vegetative portions of the fungi causing disease are deep within the tissues of the plant beyond the reach of destruction. Hence sprays are of value largely to prevent the entrance of parasites into the healthy tissues and not as agents to kill them after they have once gained entrance. To be successful the spray must be on the fruit or foliage in advance of the spore of the fungus.

For many years bordeaux mixture has been practically the only spray used on orchard trees for the control of fungous diseases. While it has proven in every way efficient in controlling most of the destructive fungous diseases of the orchard, it has been found that the fruit and foliage of certain varieties of apples are frequently injured by the spray. As a rule the beneficial effects resulting from disease control have far outnumbered the ill effects of spray injury. That certain varieties of apples are susceptible to spray injury, or bordeaux injury as it is frequently called, especially if rainy, damp or cloudy weather is experienced at or immediately following the application of the spray, has been held responsible in a considerable measure for the lack of more general adoption of spraying by Maine orchardists. In too many cases the fact that many varieties (see list on p. 346) are seldom, if ever injured by bordeaux mixture has been entirely overlooked. Neither has it been understood that the danger from bordeaux mixture can be minimized largely, in many seasons, by applying the spray only during periods of bright, sunny weather, and avoiding its use, if possible, when there are several, successive, cloudy, rainy days.

However, there has been and is a demand for a fungicidal spray which will control the various plant diseases and still cause no injury to the foliage and fruit of the more tender varieties. Experiments begun by Scott* in spraying apples and peaches the latter being very susceptible to bordeaux injury, and later taken up by others in various parts of the country, indicate that in the different lime-sulphur sprays we have the promise of something which may control certain of our orchard diseases nearly if not quite as well as bordeaux mixture and if not used

* Scott, W. M. Self-boiled Lime-sulphur as a Promising Fungicide. Bureau Pl. Ind., U. S. D. A., Cir. 1, pp. 1-18. 1908.

too strong be practically free from the production of spray injury.

Therefore, it is recommended that all orchardists who have experienced trouble with bordeaux injury in the past, and others who wish to spray varieties which are known to be susceptible to spray injury, give the lime-sulphur treatment a thorough trial. It will be noted, however, that lime-sulphur as suggested for summer spraying for fungous diseases is used in a much more diluted form than for winter spraying for insect pests. The more concentrated sprays are far too strong to be used on the tender foliage and fruit.

The above recommendation should in no way be construed as advising against the use of bordeaux mixture where it has always been used without injury in the past or with those varieties of apples which the experience of others indicates that there is little or no danger of bordeaux producing any injurious effects on the fruit or foliage. Apple scab is the greatest factor to be considered in Maine orchard spraying, and in the experience of the writers bordeaux is, as a rule, more effective than lime-sulphur in controlling this disease under the weather conditions which prevail in this State. There is no reason for discarding bordeaux for lime-sulphur except to attempt to avoid spray injury on those varieties of apples upon which it is likely to occur. Even with these it is recommended that bordeaux mixture still be used for the first spraying before the buds open, followed by lime-sulphur for the later sprayings upon the foliage and fruit. If, however, the orchard has received a spring application of the more concentrated lime-sulphur wash for insects before the buds begin to swell, the early application of the bordeaux is probably unnecessary.

THE PREPARATION OF SPRAYS.

There is no part of the management of an orchard which requires more intelligent and careful work than the preparation and use of sprays. If the owner cannot attend to this part of the work himself he should put it in charge of some thoroughly competent person. Many failures from spraying have resulted from the fact that the sprays were not properly made and applied. The formulae given should be followed with care, the operator first satisfying himself that he understands each step

of the process before attempting to prepare a quantity of spraying material. All material should be carefully weighed and measured.

BORDEAUX MIXTURE, FORMULA I.

Copper sulphate (blue vitriol).....	3 pounds
Fresh stone or lump lime.....	3 “
Water	50 gallons

It will be noted that the bordeaux mixture here recommended is only three-fifths as strong as that commonly used on potatoes in this State and formerly recommended by this and other Stations for use upon the apple. This is because later work has shown that the weaker bordeaux controls the apple scab nearly as well and is much less likely to injure the fruit and foliage than the stronger. The 5-5-50 formula should still be used upon potatoes, and upon apple trees before the buds open.

Metal vessels should not be used in the preparation of bordeaux mixture. Empty kerosene barrels with one head removed (50 gal. capacity) are more commonly used, but larger wooden tanks are frequently employed. For convenience these should hold multiples of 50 gallons, or have the capacity in 25 or 50 gallon units indicated by tacking a short, thin strip of wood at the required height on the inside of the tank.

Slake the lime and dissolve the copper sulphate in separate barrels and then dilute each with half of the water. It is necessary to strain the milk of lime solution after slaking.* This

*The most satisfactory strainer that the writers have ever used is constructed as follows: Make a box about 12-15 inches long, without ends and just small enough to slide easily inside the top of the dilution barrel. Then one end of the box is sawed off at a considerable angle, making one side much shorter than the other. No. 50 brass wire strainer cloth is then tacked securely over this end. (Pieces of discarded wire screen cloth used on the machines in paper mills are excellent for this purpose but are of somewhat finer mesh). Two pieces of board about 2 inches wide, and long enough to reach across the top of the barrel are then nailed to the sides close to the other end. The completed strainer is then placed in the top of the dilution barrel with the wire bottom down and the two cross pieces extending across the top of the barrel and serving as supports. With a little care such a screen never troubles with clogging as the wire bottom is placed at such an angle that the solid particles are continually washed to the lower side of the screen leaving the remainder unclogged.

is best done in making the dilution by using a separate barrel for this purpose and using the dilution water to wash the material through the strainer. If the lime is of good quality and well slaked most of it will pass through the strainer, but with the best there will be a slight residue which may be thrown away. If arsenate of lead is to be added to the bordeaux as an insect poison the required quantity may be wet up and washed through the strainer with the lime.

When ready to use the mixture, the dilute lime and copper sulphate solutions are quickly mixed together and thoroughly stirred. This may be done by rapidly dipping up a pailful of one and then a pailful of the other solution and pouring into the mixing or spray tank while a second person agitates the mixture. *Never pour concentrated milk of lime and copper sulphate solutions together.* The above procedure is recommended only where a single barrel or at the most only a few barrels of spray mixture are needed at a time. Where any quantity of bordeaux is required stock solutions and, if possible, the elevated mixing platform should be resorted to.

Stock solutions. When lime and copper sulphate are combined in the form of bordeaux the mixture should be used with as little delay as possible on account of deterioration. On the other hand, as long as the solutions are kept separate and covered to keep out rain and to prevent evaporation they may be stored for an indefinite period. Hence concentrated stock solutions of lime and copper sulphate may be prepared, at any convenient time, sufficient for one application to the entire orchard or for the entire season if the orchard is not too large. Stock solutions are made up so that each gallon when thoroughly stirred carries a known amount of lime or copper sulphate as the case may be—as a rule either one pound or two pounds to the gallon.

If it is intended to make stock solutions carrying one pound to the gallon place 50 pounds of fresh stone lime in a 50-gallon cask, slake, dilute to thin whitewash, strain while hot and make up to 50 gallons. If arsenate of lead is to be used with the spray the proper amount may be wet up and washed through the strainer with the dilution water. *Always stir thoroughly, taking particular care to get to the bottom of the cask, before dipping out any of this stock solution,* otherwise the first will

carry less than a pound to the gallon and the last more. In another 50-gallon barrel suspend 50 gallons of copper sulphate crystals in a sack close to the top, and then fill the barrel with water. The copper sulphate suspended in this way will dissolve in a few hours, or over night, while if it is placed in the bottom of the barrel it will dissolve with difficulty unless the solution is constantly stirred. Some prefer to make stock solutions carrying 2 pounds of lime or copper sulphate to the gallon. In that case use 100 pounds of material instead of 50 in each 50-gallon barrel.

To prepare the mixture from the stock solutions, assuming that they carry a pound to the gallon and a 3-3-50 bordeaux is to be made, stir thoroughly and for each 50 gallons of spray dip out 3 gallons of the lime stock into one dilution barrel and 3 gallons of the copper sulphate stock into another, add water to make up to 25 gallons each, then quickly and thoroughly mix. If the stock solutions carry 2 pounds of material to the gallon use $1\frac{1}{2}$ gallons of each to 50 gallons of mixture.

Elevated mixing platform. Much of the labor of making bordeaux may be avoided, and better facilities furnished for securing a perfect mixture by the use of the elevated mixing platform. This requires four solid posts resting on flat stones or set in the ground and extending above the surface somewhat above the top of the spray tank, to form the supports of the four corners of the platform. These posts should be solidly braced by means of crossed boards nailed from one to the other. To the tops of the posts on the outside around the four sides, pieces of 2x6 or equally strong material are spiked with the edges up—these to serve as sills. Other cross sills may be necessary for added strength, varying with the size of the platform. Lastly a floor of good sound plank is laid over the sills. The size of the platform varies somewhat with the location and needs of the user, but it should be large enough to accommodate the barrels for the stock solutions and dilution barrels, and leave sufficient room to move about, 10x12 feet is large enough for most places. Fig. 266 shows the platform in use at Highmoor Farm. The higher platform with the large tank is for water storage.

The dilution vessels should be large enough so that both together will contain enough liquid to fill the spray tank. That is, for a 100-gallon tank 2 50-gallon casks will be required for

dilution purposes. For a 200-gallon tank 4 50-gallon casks may be used. The dilution barrels are placed on the extreme front edge of the platform. A hole should be bored in a stave close to the bottom of each of these barrels. This hole should be large enough so that at this point a piece of rubber tubing of an inch or more internal diameter can be attached. The attachment may be made by screwing a short piece of brass pipe into the hole in the stave and sliding the rubber tube over the portion that projects outside. For added security against leaking a brass lock-nut with rubber washer may be screwed up against both inside and outside of the stave if the hole is not too close to the bottom. The rubber tubing should be long enough to reach well above the top of the dilution barrels and while the latter are being filled the free end should be held by means of a string tied around the tube near the end and hooked over a nail driven into the top end of one of the staves.

When the dilution barrels are filled the spray tank is driven alongside the platform, as close to them as possible. Standing on the spray tank the operator removes the free ends of the tubes from their support and inserts them quickly in the opening in the top of the spray tank. In this way the tank is rapidly and easily filled, and the best possible conditions supplied to secure a high grade mixture. In Fig. 266 the hose from the two barrels on the right are let down as in filling the spray tank. On the next barrel to the left the hose is hooked up as already described. In place of the hose large iron or brass faucets may be screwed to the bottom of the barrels and so arranged that they will open into a common conductor leading to the spray tank. However, on account of the corrosive action of the mixture the iron faucets will soon rust out.

Where running water is available it may be conducted to the platform with a garden hose or a metal pipe may be used, so arranged that it may be taken down or emptied before cold weather. Where running water is not available the platform may be erected alongside of a well, cistern, stream or pond. A cheap iron pump is placed on the platform, high enough so it will deliver over the tops of the barrels and connected with the water supply with a lead pipe.

BORDEAUX MIXTURE WITH IRON STICKER, FORMULA 2.

Copper sulphate (blue vitriol).....	2 pounds
Iron sulphate (copperas).....	2-4 “
Fresh stone or lump lime.....	4-6 “
Water to make.....	50 gallons

This formula is proposed and recommended by Dr. A. D. Selby of the Ohio Experiment Station. It has not been used by the writers in Maine, but Doctor Selby makes the following statement with regard to it: *

“In this spray the iron sulphate is added in order that it may be precipitated by the lime and serve as a more complete sticker than is provided by standard bordeaux mixture. It would appear possible by the weak solution as given for the copper compound and by this possible efficient sticker to make the reduced amount of the copper sulphate do the work as fungicide just as effectively and with less risk of foliage injury than with standard bordeaux mixture. Trials made up to this time upon apples in full foliage, upon grapes, and upon potatoes indicate that the spray is efficient. *The iron sulphate is not considered a fungicide.*”

Where spray injury upon apple trees is experienced and the orchardist does not wish to go to the trouble of preparing his own lime-sulphur sprays or go to the expense of purchasing the prepared brands of lime-sulphur, a trial of this modified form of bordeaux mixture is suggested.

Lime-sulphur sprays. The orchardist who desires to use lime-sulphur compounds for summer spraying may choose one of the following: a self-boiled lime-sulphur, a home-cooked, or a factory-cooked concentrated material which must be diluted before it is applied. The first is comparatively easy to prepare but less effective than the other two. The home-cooked concentrated may be prepared some time before needed and later diluted as fast as required for use. It has the disadvantage of being somewhat more difficult to prepare, requiring some form of cooker and other pieces of apparatus. Of the factory-cooked concentrated material there are several brands on the market which seem to equal the home-cooked in efficiency and in freedom from the production of spray injury if used in sufficient

* Selby, A. D. Ohio Exp. Sta. Bul. 214, p. 358, 1910.

dilution. On the other hand, the commercial brands of lime-sulphur are, of necessity, the most expensive. This is partly offset in the saving in time and trouble in preparing the material. All that is necessary to do with these commercial brands is to dilute and apply.

Self-boiled lime-sulphur. The self-boiled lime-sulphur is the least effective in controlling apple scab according to the experience at this Station, but to prepare it requires no more apparatus or skill on the part of the maker than in preparing bordeaux mixture.

SELF-BOILED LIME-SULPHUR, FORMULA 3.

Sulphur	10 pounds
Fresh stone or lump lime.....	10 "
Water	50 gallons

To be applied without farther dilution.

The following is the method of preparation as described by Scott* and as used by the writers in the experiments mentioned on p. 349:

"The mixture can best be prepared in rather large quantities—say 20 pounds, or even 40 pounds at a time—so as to get enough heat to produce a violent boiling for a few minutes. Place the lime in a barrel and pour on enough water (about 3 gallons to 20 pounds) to start it slaking and to keep the sulphur off the bottom of the barrel. Then add the sulphur, which should first be worked through a sieve to break up the lumps, and finally enough water to slake the lime to a paste. Considerable stirring is necessary to prevent caking on the bottom. After the violent boiling which accompanies the slaking of the lime is over, the mixture should be diluted ready for spraying, or at least enough cold water added to stop the cooking. Five to fifteen minutes are required for the process, according to whether the lime is quick acting or sluggish. The intense heat seems to break up the particles of sulphur into about the physical condition of precipitated sulphur and the violent boiling makes a good mechanical mixture of the lime and sulphur. Only a small percentage of the sulphur—enough to improve the adhesiveness of the mixture—goes into solution, but if the hot mass is allowed to stand as a thick paste the sulphur continues to unite with the

* Scott, W. M., Bureau Pl. Ind., U. S. D. A., Cir. 27, p. 5, 1909.

lime, and at the end of thirty or forty minutes enough of the reddish liquid is produced to burn peach foliage in some cases. Hence the necessity for cooling the mixture as soon as the lime is well slaked. The finely divided sulphur in mechanical mixture with the lime is depended upon for the fungicidal action rather than the sulphide in solution, the latter being harmful to foliage except in very dilute form."

The mixture must be strained and particular care taken to wash all of the particles of sulphur through the strainer. The form of strainer, with the sharply inclined bottom, described in the foot-note on p. 380, is very satisfactory for this purpose. Maine lime is rather slow to heat up but slakes well and thoroughly after it is once started. Therefore, when employed for this purpose a few dippers of hot water may be used at first to start the lime off briskly. If all hot water is used there is some danger of bringing too much sulphur into solution and injury to the foliage results when applied to the more tender varieties. The diluted mixture may be kept for a week or more without deterioration. On account of the character of the mixture great care must be taken to see that it is constantly and thoroughly agitated while being applied. Otherwise much of the suspended sulphur will settle to the bottom.

Home-cooked concentrated lime-sulphur. For the average farmer using only a small quantity it is probably wiser to purchase the factory-cooked concentrated material for dilution than to attempt its manufacture himself. However, in the case of large orchards where the expense for the ready-made article would be large or where the user has had some experience or training in similar lines of work its preparation may well be attempted. Before doing so it would be well to obtain and read Bulletin 99 of the Pennsylvania Station, State College, Pa., and Bulletin 320 of the New York Station, Geneva, N. Y. A kettle or some form of cooker is necessary and, whether one prepares his own concentrate or buys the ready prepared, some form of specific gravity apparatus as the Baumé hydrometer for testing the strength of the concentrated mixtures is essential. These latter may be obtained from various dealers in scientific apparatus. Those used by this Station were purchased of the Dausch & Lomb Optical Co., Rochester, N. Y. A pamphlet describing their use comes with the instruments, or may be obtained free

on request. The cost for the complete hydrometer outfit need not exceed \$1.00 to \$1.25.

Professor Whetzel and his associates at Cornell University as the result of their studies and experiments have done much to stimulate interest in this class of fungicides. The following method of preparing the concentrated mixture is adapted from a paper read by Professor Whetzel before a recent meeting of the New York State Fruit Growers' Association, and is based on the recommendations of Professor Cordley of the Oregon Station, who has probably done more than any one else to develop lime-sulphur spraying for fungous diseases, especially on the Pacific coast.*

HOME-BOILED CONCENTRATED LIME-SULPHUR, FORMULA 4.

Sulphur (best finely ground).....	110 pounds
Fresh stone or lump lime.....	55 "
Water to make.....	60 gallons

Caution. *Must be greatly diluted for use on apple foliage, see below.*

Slake the lime in the kettle, make a paste of the sulphur with a little water, then add this paste and the remainder of the water to the lime solution in the kettle. Boil 30-45 minutes or until the sulphur is dissolved and then after the sediment has been allowed to settle pour off the clear, amber liquid which should be approximately 45 gallons and test about 30° Baumé. The liquid may test higher or lower than this, varying with the concentration, so it should always be tested. *The liquid should not be tested while hot but should be cooled to about 60° F.* The reading on the hydrometer should be taken at the general surface of the liquid at which it is supported.

If the concentrate is not intended for immediate dilution it should be at once stored in tightly closed containers till ready for use. The amount of dilution will, of course, depend upon the density of the concentrate. The following table supplied by Cordley gives the amount of dilution of concentrated lime-sulphur stock solutions of different degrees of density according to the Baumé scale for winter and summer spraying of apple trees. Only the dilutions indicated in the right-hand column should be used for trees in leaf.

* Cordley, A. B. Oregon Exp. Sta. Bul. 108, p. 16, 1910.

TABLE FOR DILUTION OF CONCENTRATED STOCK SOLUTIONS OF VARYING DENSITIES.

Stock Solution Baumé Scale Reading.	Winter Strength Leaves Off. Dilution.	Summer Strength Leaves On. Dilution.
32°	1-12	1-30
31°	1-11	1-29
30°	1-10	1-28
29°	1-9½	1-27
28°	1-9	1-26
27°	1-8½	1-25
26°	1-8	1-24
25°	1-7½	1-23
24°	1-7	1-22
23°	1-6½	1-21
22°	1-6	1-20

Not counting the initial cost of the apparatus it is estimated that at the prevailing price of labor and materials home-made, concentrated lime-sulphur can be prepared for from \$3.00 to \$3.50 per barrel of 50 gallons. If the fact that 50 gallons of concentrated material will when diluted for summer use make from 1300 to 1500 gallons of spray, is remembered, it will be seen that home-cooked lime-sulphur is considerably less expensive than bordeaux mixture.

Commercial concentrated lime-sulphur. During the past two years several firms have placed on the market different brands of concentrated lime-sulphur similar to the home-boiled article. Quite a number of these have been tested experimentally and as a rule these have given quite favorable results when compared with the latter. While directions may be furnished with the commercial brands, they should always be tested with the hydrometer and the dilutions made on this basis, using the table given above.

"Variations in the degree of concentration of the commercial lime-sulphur mixtures may occur with different barrels of the same brand. Some companies compounding these sprays have apparently not been able to produce a wash of definite strength or have failed to realize the importance of maintaining a uniform grade for their product."*

* Parrot, P. J., N. Y. Exp. Sta., Bul. 320, p. 423, 1909.

All other things being equal, an article testing rather high and relatively free from sediment would be the more economical to buy. Hydrometers do not detect soluble impurities added to lime-sulphur concentrates for the purpose of increasing their densities. The national law against the adulteration of fungicides and insecticides will doubtless prevent this difficulty, but if there is any reason to suspect the character of any brand of goods a sample should be submitted to a chemical examination.

Before buying any of these concentrated sprays the purchaser should *make sure that it is a lime-sulphur compound*. At least one other concentrated substitute for bordeaux the name of which indicates that it is some sort of a soluble sulphur preparation has been known to produce disastrous results when applied to apple trees with arsenate of lead in even greater dilutions than recommended by the manufacturers.

Dust sprays. In hilly, rocky orchards where heavy spraying machinery can be hauled with difficulty, and in localities where a plentiful, near-by supply of water is not available, spraying with liquid sprays is attended with considerable difficulty. To meet this difficulty various dry sprays, said to contain approximately the same active constituents as liquid bordeaux mixture, have been advocated from time to time. These are in the form of a very fine powder to be blown forcibly on to and within the foliage by means of specially designed machines, the essential parts of which consist of a rapidly rotating fan, a hopper to hold the powder, and a line or lines of hose to conduct the air blast carrying the powder up among the tree tops.

In some instances favorable results have been reported for the dust sprays, but in the opinion of the writers their use is not advisable. In 1907 one of us (M.) demonstrated the marked inferiority of the dust sprays as compared with standard 5-5-50 liquid bordeaux for the control of the late blight of the potato.* At the same time the late Prof. W. M. Munson of this Station was conducting experiments with dust sprays on apple trees for scab. While these results were never published they were in general similar to those secured on potatoes. Crandall has, however, made and published the results of a very thorough study of the relative merits of liquid bordeaux and

* Morse, W. J. Me. Agr. Exp. Sta. Bul. 149, p. 289, 1907.

dust sprays for orchards in Illinois. The following paragraph is a concise summary of his conclusions.*

"The results of the experiments are sufficiently decisive to warrant the conclusion that the dust spray is absolutely inefficient as a preventative of injury from prevailing apple fungi, and that it is considerably less efficient as an insect remedy than is the liquid method of applying arsenites."

WHEN TO SPRAY AND WHAT TO USE.

If supplemented with proper orchard sanitation apple scab and practically all of the other serious fungous diseases of the fruit and foliage of Maine orchards may be quite successfully controlled by the following procedure:

Apply the first spray when the leaves are unfolding, the second immediately after the blossoms fall and the third 10 days or two weeks thereafter. If the season is very wet a fourth spraying after another interval of 10 days or two weeks may be necessary.

For varieties resistant to spray injury use 3-3-50 bordeaux mixture, Formula 1. For more tender varieties self-boiled lime-sulphur, Formula 3; home-cooked lime-sulphur, Formula 4, diluted to summer strength, or commercial brands of lime-sulphur diluted to summer strength, are suggested. Where scab is very prevalent or spraying has been neglected in the past it is advisable to substitute for the first spraying with lime-sulphur an application of 5-5-50 bordeaux made a little earlier in the season before the leaf buds open. It is claimed by those who have experimented with home-cooked or commercial lime-sulphur diluted to winter strength and applied just before the leaf buds open that they are also very effective in killing the spores of fungi on the twigs in addition to destroying scale and other insects.

Insecticides with fungicides. When applying the fungicides described above it is advisable to add some form of poison to the first two or three applications after the leaves begin to show, to kill the bud moth, canker worm, tent caterpillar, forest caterpillar, etc. Paris green and lead arsenate are both effective but for several reasons the latter is preferred by many for use on apple trees. One to three pounds of lead arsenate to 50 gallons

* Crandall, C. S., Ill. Exp. Sta. Bul. 106, p. 240, 1906.

of bordeaux mixture or lime-sulphur may be used. In the case of lime-sulphur it should not be added till it is diluted ready to apply. In experimental work and in the dryer climates of some Western states one pound of lead arsenate has been found to be sufficient for 50 gallons of spray, but in practice with average farm conditions two to three pounds are usually required.

HOW TO SPRAY.

To do really good and effective work in orchard spraying requires constant care and watchfulness on the part of the operator, and also requires a certain amount of practice to secure the best results. Thoroughness is very essential, but by thoroughness is not meant drenching the tree. The spray should be delivered with a constant, strong pressure, issuing from the nozzle in a fine mist, the finer the better. The operator after a little experience will find that if he moves the extension rod carrying the nozzles at the proper rate and the right distance removed from the leaves he is enabled to cover them thoroughly with a fine mist-like coating, provided the proper type of nozzle is used, and there is no tendency for the mixture to gather together in large drops on the leaves or drip off from the edges. While avoiding applying enough of the spray to cause dripping care should be taken to reach the foliage and limbs on all parts of the tree. It is impossible to do thorough spraying in trees which have not been properly pruned and in which the tops are filled with water-sprouts and interlocking branches.

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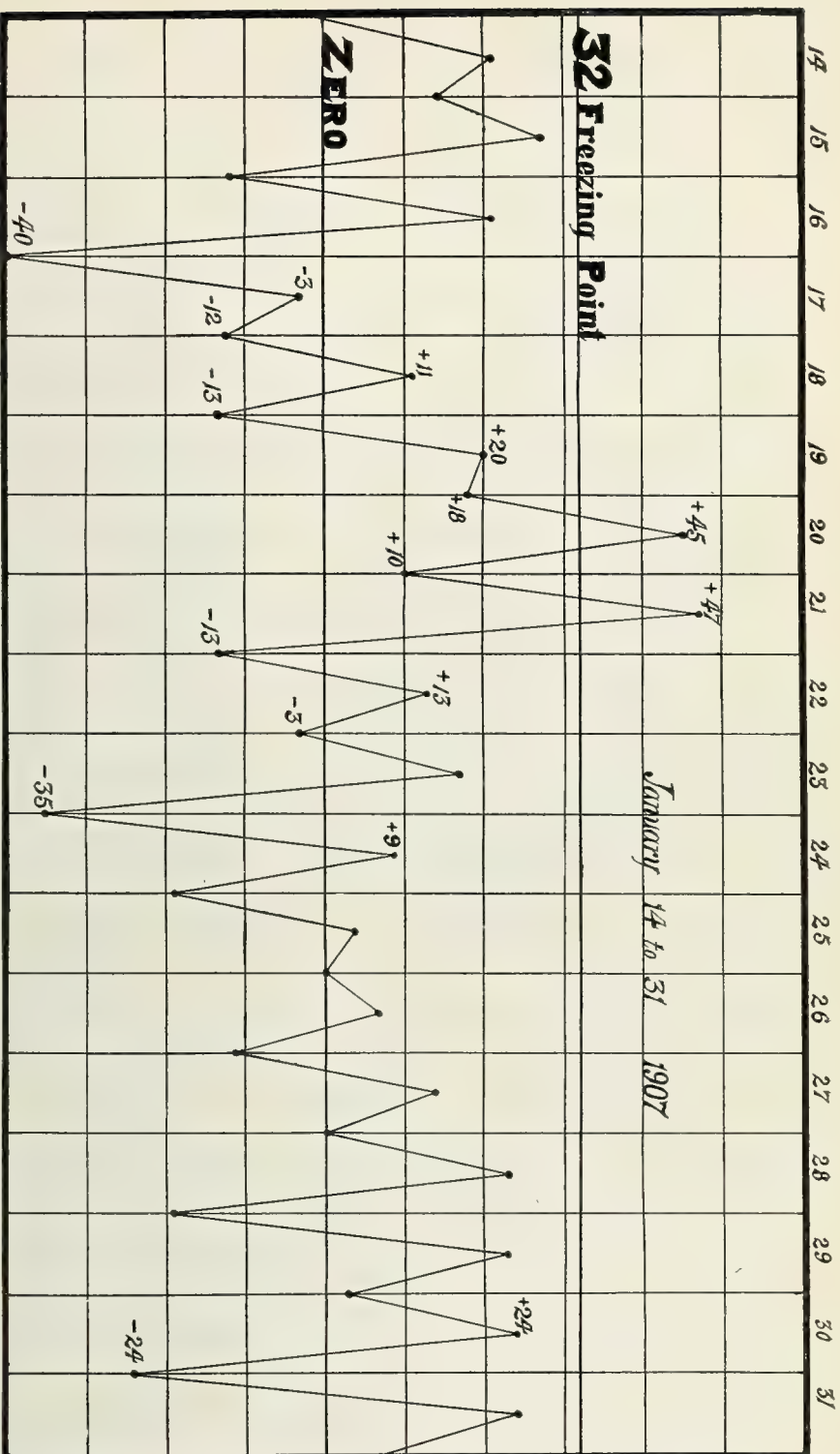


Fig. 237. Maximum and minimum temperatures in degrees F., Orono, Me., Jan. 14-31, 1907.



Fig. 238. Crotch injury of apple tree.

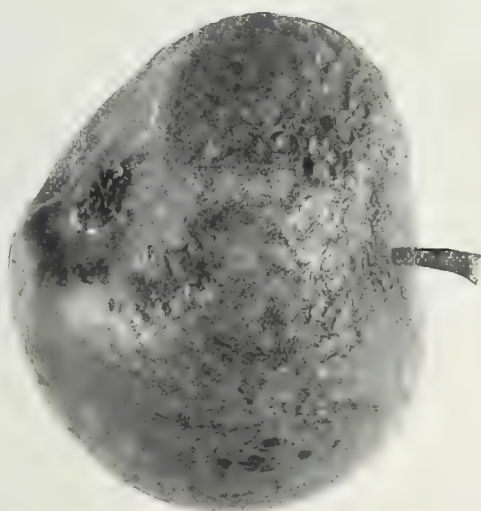


Fig. 239. Spray injury on fruit.

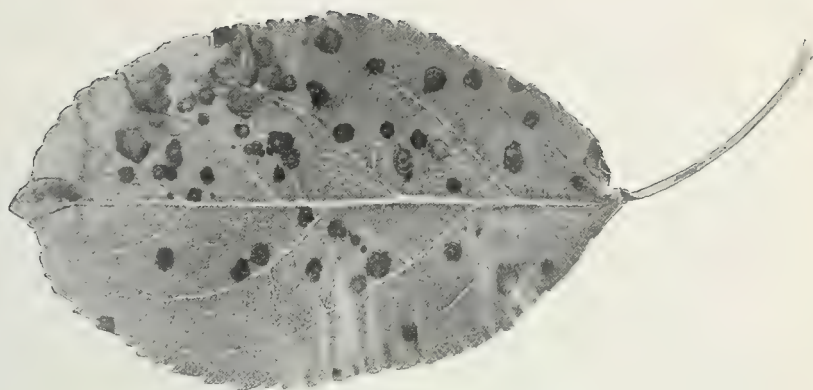


Fig. 240. Spray injury on leaves.

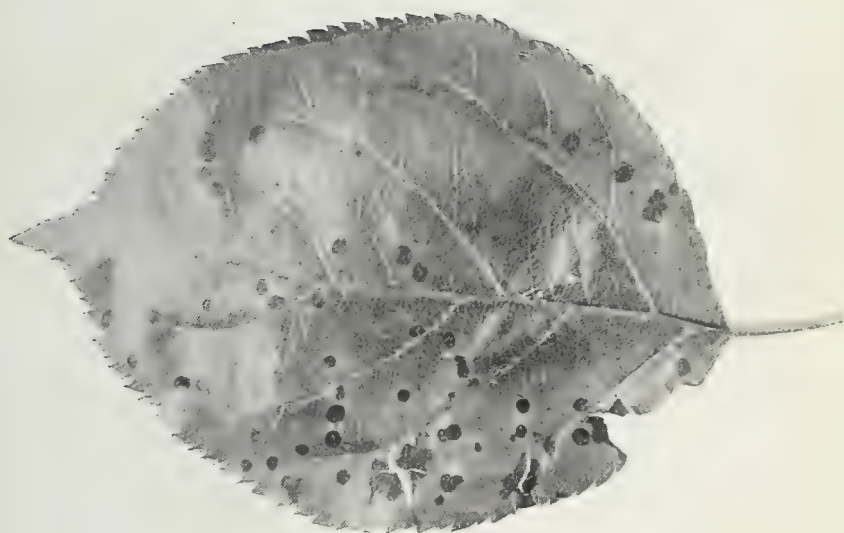


Fig. 241. Spotting of leaves by fungus.



Fig. 242. Baldwin spot.



Fig. 243. *Cylindrosporium* fruit spot.



Fig 244. Lichens on an apple branch.



Fig. 245. Malformation and cracking resulting from a bad attack of scab.
The surface of the fruit is nearly covered with scab spots.

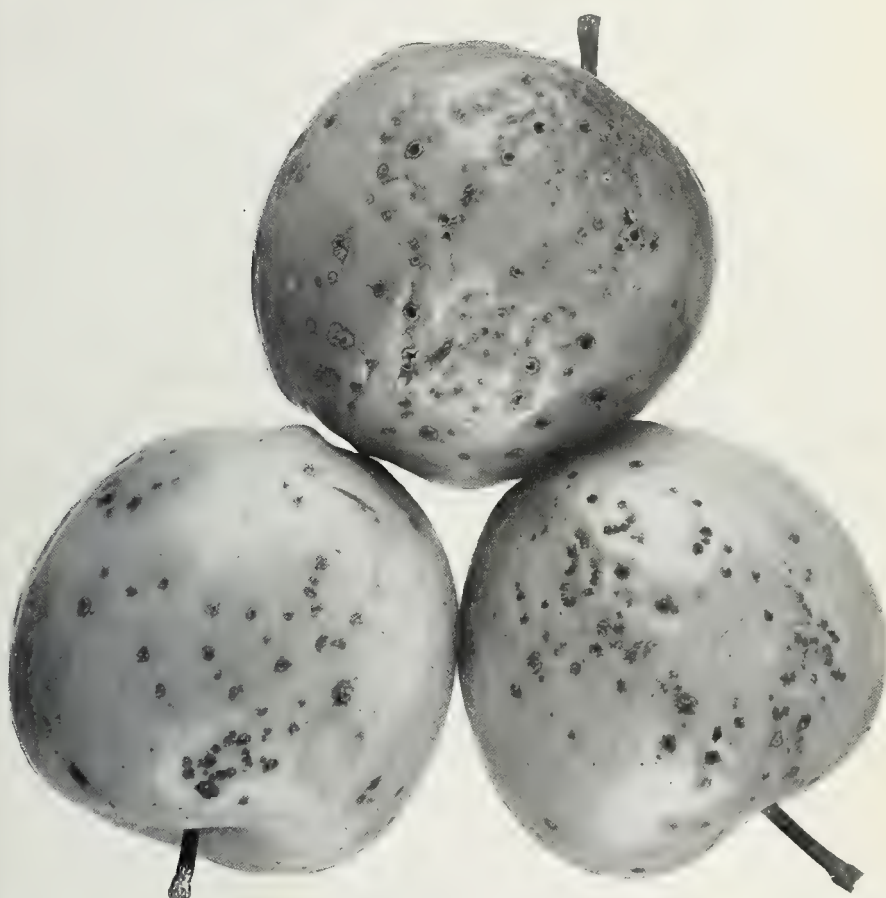


Fig. 246. Scab developed in storage.



Fig. 247. Scab on apple leaves.



Fig. 248. Powdery mildew on apple leaves.

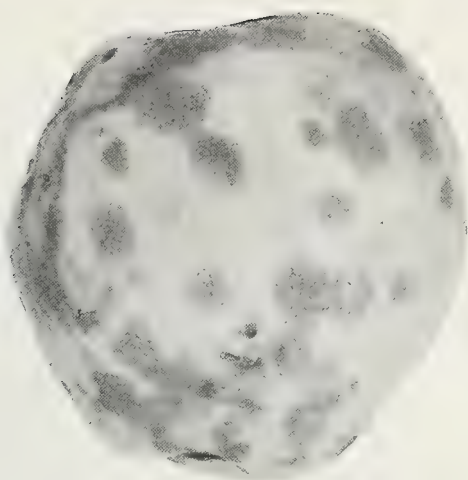


Fig. 249. Sooty blotch.



Fig. 250. Black rot.



Fig. 251. Blue mold decay.

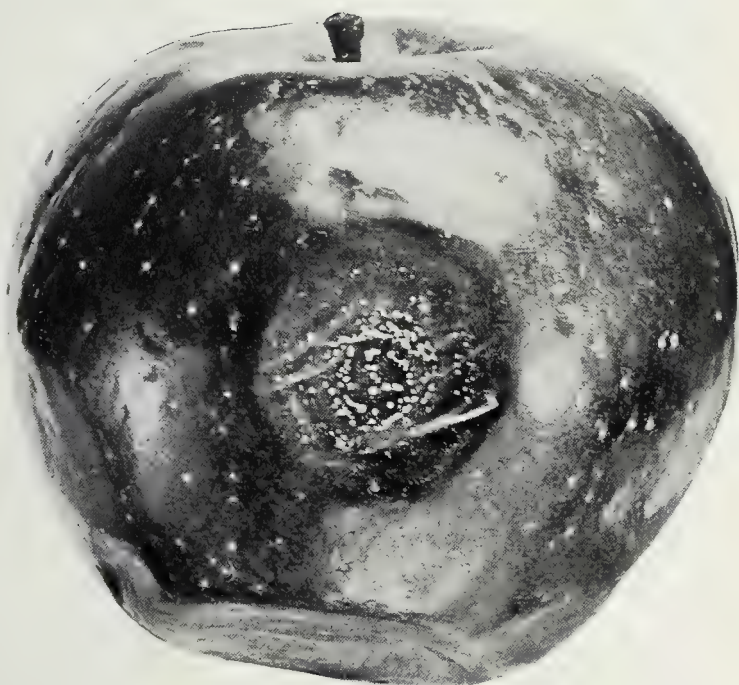


Fig. 252. Bitter rot.



Fig. 253. Brown rot resulting from artificial inoculation.

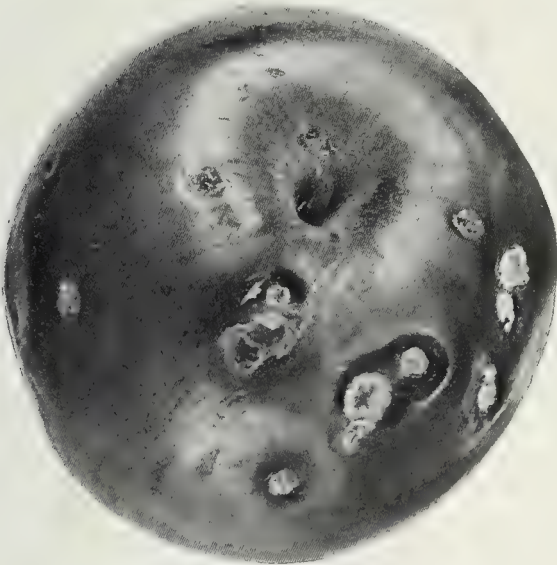


Fig. 254. Pink rot following scab.

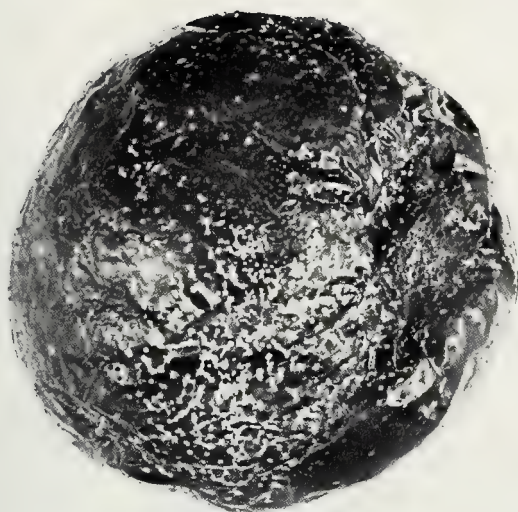


Fig. 255. Phoma decay.

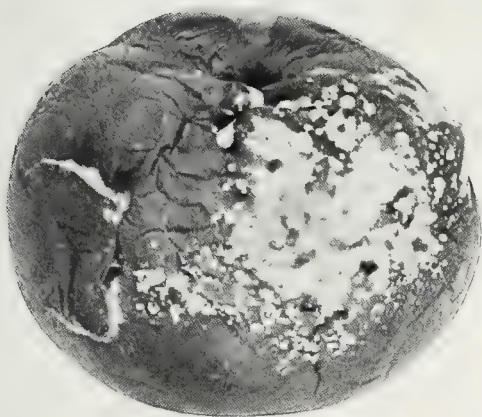


Fig. 256. Fusarium decay.



Fig. 257



Fig. 258



Fig. 259

Different stages in the formation of *Sphaeropsis* limb cankers.



Fig. 260

Bitter rot. Stem of young tree, one month after inoculation with fungus.



Fig. 261

Myxosporium twig-blight



Fig. 262



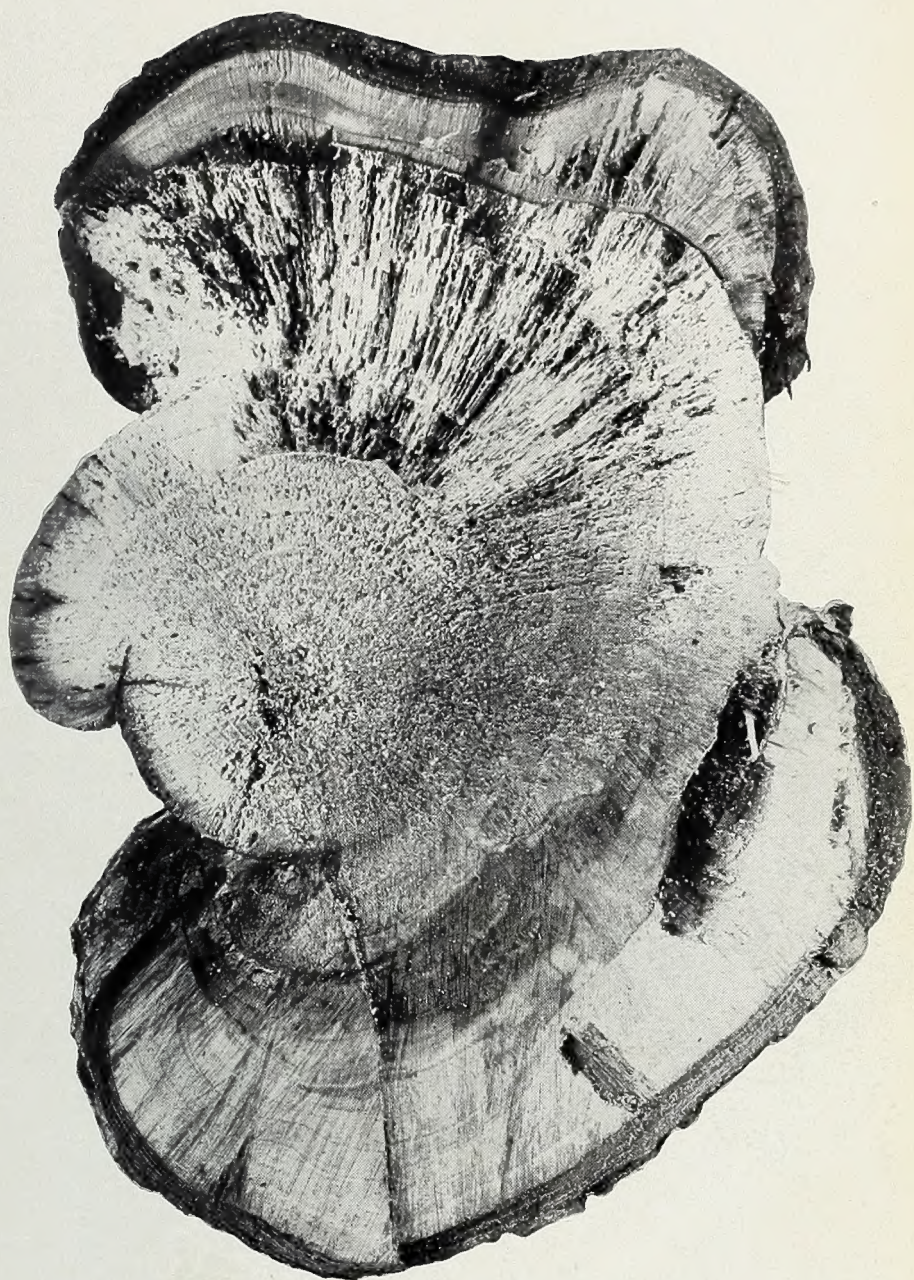
Fig. 263



Fig. 264

Coryneum. Fig. 262. Branch 3 months after inoculation. Fig. 263. Young canker produced naturally. Fig. 264. Twig blight, caused by Coryneum.

Fig. 265. Decay of the heart-wood resulting from fungus infection of surface wounds



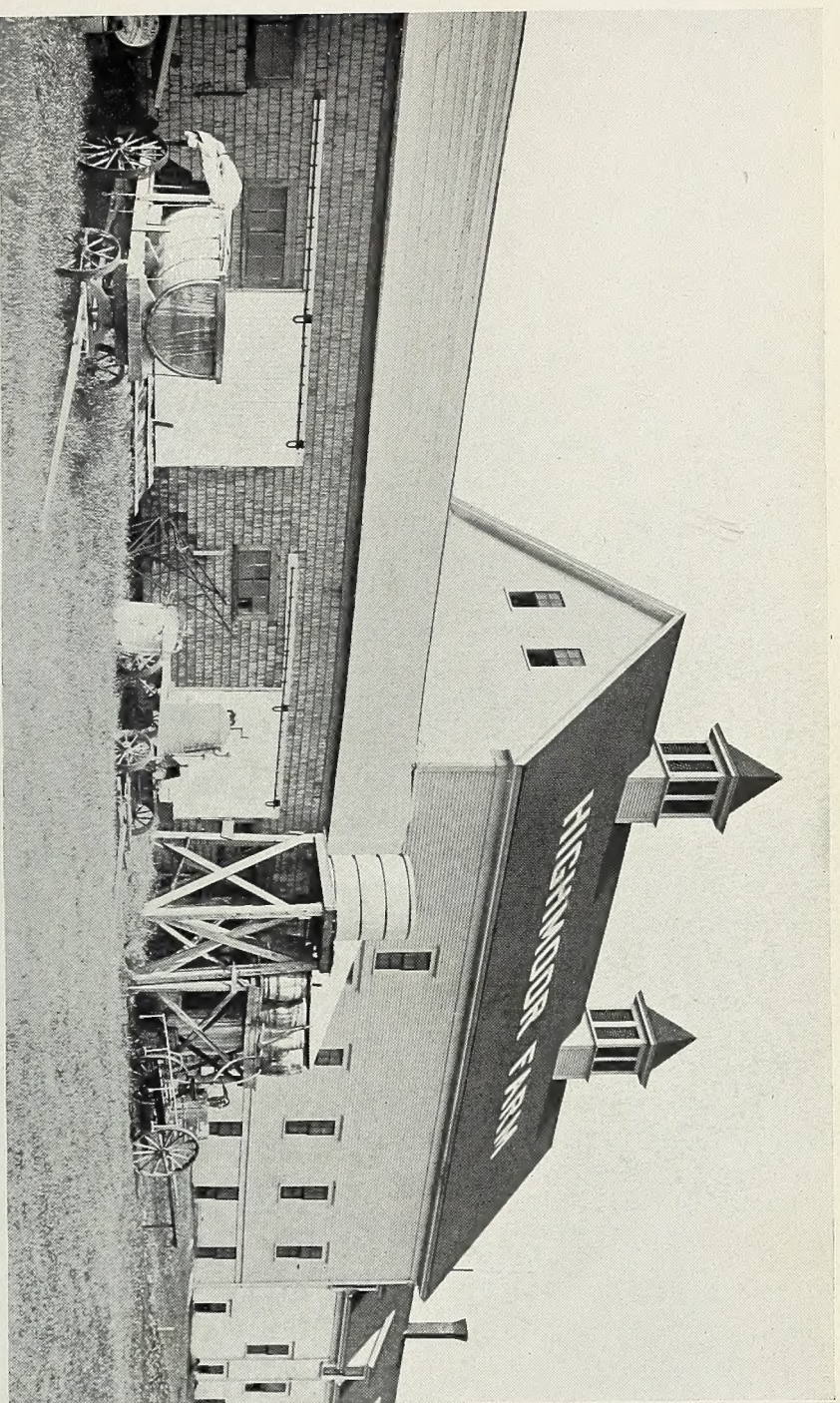


Fig. 266. Elevated platform, at the right, for preparing Bordeaux Mixture. The larger tank on the higher platform is for water storage.

